

## APPENDIX A

The following table summarizes examples of microfluidic components and structures that can be made available in a library for design capture.

Component/ Structure	Brief Description	Reference(s)	Figure Number(s)
ON/OFF Switches	An ON/OFF switch is open in the ON state allowing fluid flow therethrough and is closed in the OFF state to prevent fluid flow therethrough.		
	Pressure-actuated, normally open switch	Present Application  60/282,253	2A-3  7A-7E 8
	Pressure-actuated, normally closed switch	60/282,253	9A-9D
	Vacuum-actuated, normally closed switch	60/282,253	10 & 15A- 15J
	Inverted pyramid pressure amplification switch	60/282,253	39A-39D 40-41
	T-switch	Present Application	13A
Valves	Valves are provided for directing fluid flow.		
	Side-actuated valve	PCT/US00/ 17740	48A-48B
	Unidirectional valve for permitting fluid flow in one direction therethrough	60/282,253	20A-B 21 22 23
Interconnect Bridges	Interconnect bridge having a control channel with tapered element for bridging a fluid channel	Present Application	17B
Vias	Vias provided in one channel for bridging another channel.	Present Application	18B
Tapers	Fluidic taper for facilitating connection between a larger channel and a small channel	Present Application	28
Switchable Flow Arrays	Switchable flow array including fluid passages that can be selectively directed to flow in two perpendicular directions	PCT/US00/ 17740	31A-31D

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Component/ Structure	Brief Description	Reference(s)	Figure Number(s)
Multiplexer	Multiplexer having multiplexed channel flow controllers for directing fluid flow into one or more of a plurality of synthesis channels or chambers in which solid phase synthesis may be performed	PCT/US00/17740	33
Gates or Gate Structures	Fluidic logical gates can be used to perform Boolean functions.		
	Inverter for inverting an input to produce an output	60/282,253	12A
	OR gate	60/282,253	12C
	NOR gate	60/282,253	12E
	AND gate	60/282,253	12G
	NAND gate	Present Application	5A
	Latch/Flip-flop	Present Application	6A 6B
		60/282,253	33
	D-latch	Present Application	7A
Amplifiers	Fluidic pressure amplifier for amplifying pressure	60/282,253	3-4B
Pumps	Fluidic pumps are used for pumping fluid.		
	Pump operating by compression and bending of fluid chamber	60/282,253	17A-B
	Peristaltic pump with multiple control lines for pumping	PCT/US00/17740	24A-24B
	Rotary pump/mixer for mixing and incubating solutions	Present Application	21
Capacitors & Reservoirs	A capacitor or reservoir can be used for storing and releasing pressure.		
	Single-chamber high-pressure reservoir	60/282,253	24
	Two-chamber capacitor	60/282,253	28-29B
	Single-chamber vacuum reservoir	60/282,253	32
Pressure Sources	High pressure source for applying high pressure fluid to load devices	60/282,253	26
Generators	High pressure generator having stages for multiplying output pressure	60/282,253	27
Vacuum Sources	Vacuum source for driving vacuum-actuated devices	60/282,253	30

Component/ Structure	Brief Description	Reference(s)	Figure Number(s)
Fluid Chambers	Selectively addressable reaction chambers provided along flow lines and in an array for selectively directing fluid flow into one or more of the reaction chambers	PCT/US00/ 17740	28A-30
Switching Regulators	Switching regulator for performing analog functions	60/282,253	34
Sorting Devices	Sorting device for cell sorting and DNA sizing	PCT/US00/ 17740  Present Application	36  27-28
Separation Devices	Separation device for perform separation of materials	PCT/US00/ 17740	43
Cell Pen Structures	Cell pen array for storing materials within a selected, addressable position for ready access	PCT/US00/ 17740	44A-44D
Cell Cage Structures	Cell cage with pillars that permit opening of cage for transfer of cells	PCT/US00/ 17740	45A-45B
Cell Grinder Structures	Cell grinder with interdigitated posts that can be closed to crush material therebetween	PCT/US00/ 17740	46A-46B
Pressure Oscillators	Pressure oscillator for generating pressure oscillation	PCT/US00/ 17740	47
Mirror Array Structures	With appropriate control circuitry, a microfluidic structure having a light-reflecting membrane may be employed as a digital or analog mirror array.	PCT/US00/ 17740	38
Refractive Devices	Refractive device having elastomeric material capable of transmitting incident light	PCT/US00/ 17740	39 40 41

## APPENDIX B

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## General Icon Properties

Two distinguishable colors representing channels on different layers. Red in this case representing the control channel and blue the fluidic channel. There are typically two ports on each of the channels represented by white circles, or dots, sometimes outlined with black circles. Some of the icons will only have one color representing a channel only present on one layer and others will have two colors representing components composed of multiple channels on multiple layers.

### Orientation

The orientation of the components in the icons does not represent its final placement in the microfluidic design. Once the component is placed, it can be rotated with freedom to any degree (0 – 360).

## Valve



Valve

### Description:

The valve icon represents the basic switching element and consists of channels of different widths and lengths with connection points, or ports.

## T- Switch



T-Switch

### Description:

The T-Switch represents a basic component that is used to direct the incoming flow in the fluidic channel to none or one of two channels based on the state of the control channels. The channels for both the fluidic and control layer can be of different widths and lengths with connection points, or ports.

## Control Tapers



Control Taper

### Description:

The Control Taper is a basic component that allows a connection from a larger control channel to a smaller control channel or visa versa. The ends of the tapers can be of different widths based on the needed geometries of what needs to be connected.

## Fluid Taper



Fluid Taper

### Description:

The Fluid Taper is a basic component that allows a connection from a larger fluid channel to a smaller fluid channel or visa versa. The ends of the tapers can be of different widths based on the needed geometries of what needs to be connected.

## Peristaltic Pump



Pump

### Description:

The Peristaltic Pump is a basic component that allows the active control of fluid in either direction. The actual channels, both fluidic and control, can be of different widths based on the geometries required for proper operation.

## Pump and Dampener



Pump+Dampener

### Description:

The Peristaltic Pump and Dampener is a basic component that allows the active control of fluid in either direction and includes dampening channels to smoothen the flow of fluid.

The actual channels, both fluidic and control, can be of different widths based on the geometries required for proper operation.

## Multiplexers



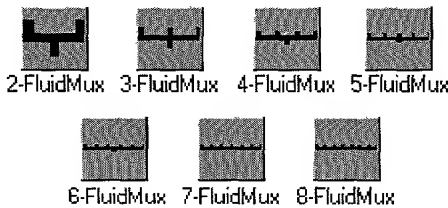
Description:  
The Multiplexers are basic component that allows the active control of fluid in 8 or 16 fluid channels based on a binary application of control signals to the control channels. The actual channels, both fluidic and control, can be of different widths based on the geometries required for proper operation. In general, these icons can be extended to cover N fluid lines controlled by  $2\log N$  control lines.

## Rotary Mixers



Description:  
The Rotary Mixers are basic components and come in different configurations based on the application needs. The Rotary Mixer comes in three basic variations of the fluid input and output ports: 2 fluid input/output (I/O), 3 fluid I/O, and 4 fluid I/O. The Rotary Mixer Sq has a different topology which allows “tiling” of the mixers and comes in two basic variations of the fluid input and output ports: 2 fluid input/output (I/O) and 3 fluid I/O. The actual channels, both fluidic and control, can be of different widths based on the geometries required for proper operation.

## Fluid Mux Connectors





## Bridges

The purpose of the Bridge component is to allow control lines to cross over fluid lines without stopping the flow of the fluid line below it. This feature enables the user to design the chip with more complexity and greater density. Note: The flow line is not completely unaffected because the membrane of the bridge component will deflect when the control line is actuated. The amount of deflection will depend upon the amount of pressure that is applied to the control line.

## Channel Arrays

The channel array provides a set of individually addressable flow lines. The number of control lines is equal to the number of flow lines for this component. The flow of the liquid within the array can be controlled in any fashion by actuating the necessary control lines.

## Control Components

The Control components allow the Control lines to be arranged in the configurations required by the user. The dimensions of these components have been established using the minimum recommended lengths for the individual components.

## Dampeners

The Dampener elements are used provide smoother flow of pumped liquid. The membrane of the Dampener element will deflect and absorb the energy caused by the closing of the valves of the peristaltic pump.

## Fluid Components

The Fluid components allow the Fluid lines to be arranged in the configurations required by the user. The dimensions of these components have been established using the minimum recommended lengths for the individual components.

## Fluid Mux Connectors

The Fluid Mux Connectors enable the user to interface the flow lines of the Multiplexer and Channel arrays to other components. They have been designed to match the flow line spacing for these components.

## Mixers

The Mixers are used to mix two or more different liquids within a closed loop. Mixing is accomplished by pumping the liquid around the closed loop. Parabolic flow of the liquid within the loop allows for fast and efficient mixing. The different Mixer orientations allow the user to arrange the mixers in various configurations (arrays, etc.) depending upon requirements.

## Tapers

The taper element is required when varying the width of the control lines or the fluid lines. This requirement is necessary because of the manufacturing process involved in making the molds for the chips.

## Multiplexers

The Multiplexer element allows the user to flow liquid in any single flow line at a given time using a predetermined control scheme. The number of control lines required for a given multiplexer can be calculated using the equation  $2(\log_2 N)$ , where

N is the number of flow lines. The advantage of the Multiplexer becomes more obvious as larger arrays are used, where the number of control lines can be significantly less than the number of flow lines.

#### Pumps

The Pump element is a peristaltic pump which is composed of three individual valves. The liquid within the flow lines are pumped by sequentially actuating the individual valves. The Pump can be used with or without the Dampener element.

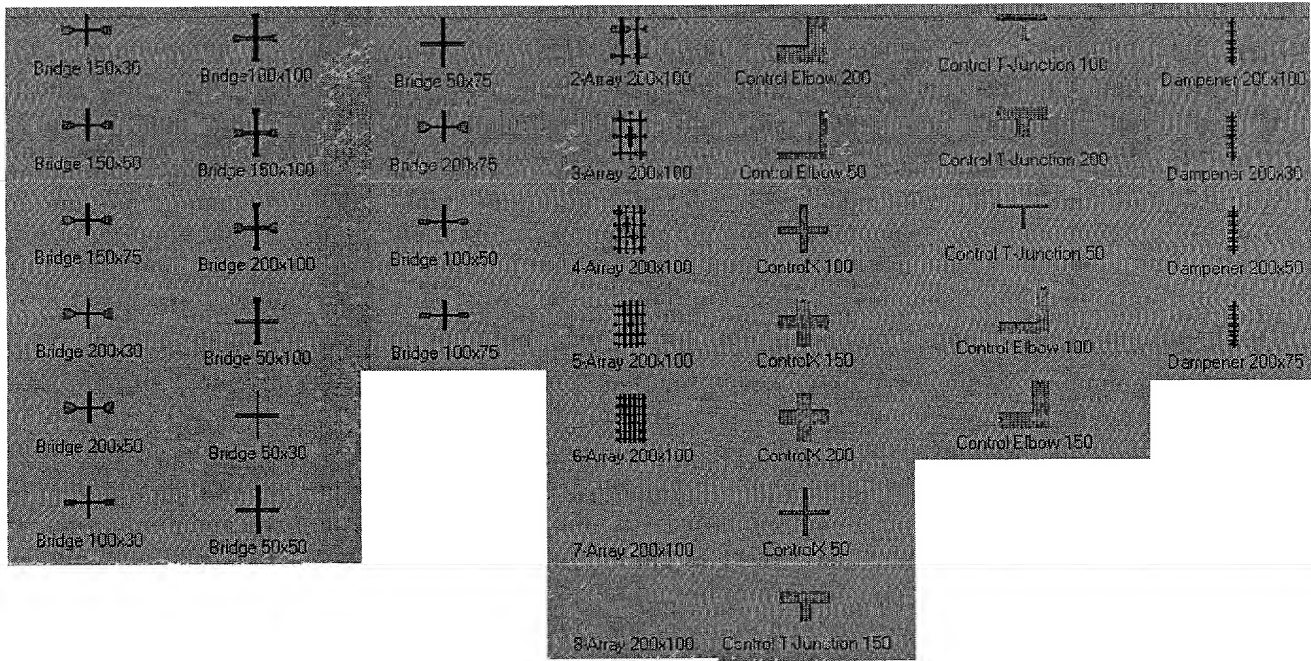
#### T-Switch

The T-Switch element allows the user to control the input of two flow lines into a single flow line or vice versa. The valve elements can be used to turn the flow of each input on and off so that the desired liquid runs through the single line or the valves can be used to separate the flow from a single line to two lines.

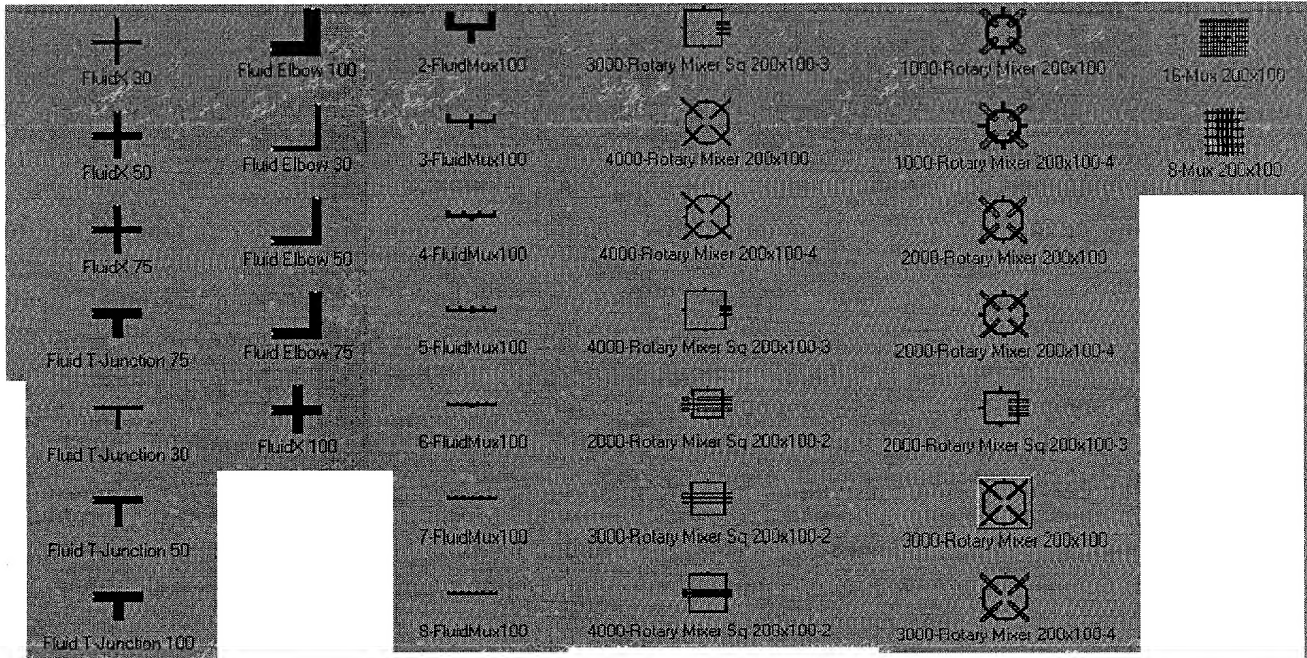
#### Valve

The valve element is used to turn the liquid flow on and off. This is controlled by providing sufficient air pressure to cause the membrane to deflect and pinch off the flow line.

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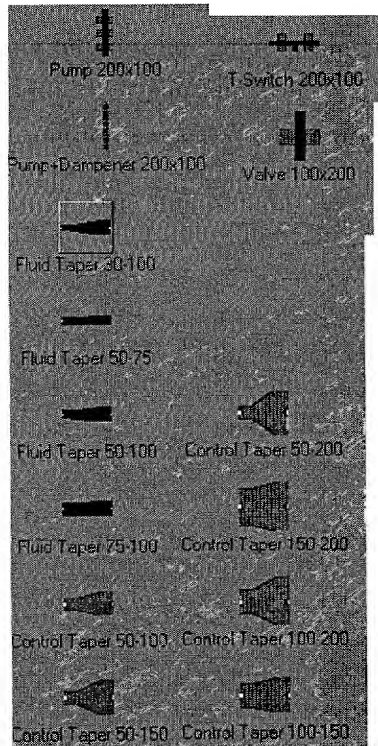


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## APPENDIX C

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# FluidArchitect™ User's Guide/Reference Manual

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## Preface

### What is a Microfluidic Chip?

Fluidigm's technology is the product of highly successful basic research. The Company's technology was developed by researchers at the California Institute of Technology who sought to create assays based on the interactions of individual molecules, cells, viruses and proteins. These assays, and the fluidic technology that enables them, proved overwhelmingly advantageous over their macroscopic counterparts and yielded functionality unavailable until now. These capabilities are the result of breakthroughs in active fluidic devices, surface chemistry, material science, and optical instrumentation. Fluidigm's microfluidic chips provide order of magnitude sensitivity increases and unparalleled flexibility by actively manipulating femtoliters of fluid.

### What is FluidArchitect?

FluidArchitect is the design automation applications portion of a revolutionary microfluidics platform that Fluidigm has built and continues to develop. This platform allows the user the ability to design customized microfluidic chips from Fluidigm's library of basic building blocks components with built in rule checking and submit the design for fabrication.

The design automation tool guides the user through the design process setup process and allows the user the ability to simply drag, drop, click, and connect components to form a customized microfluidic chip. User's who are familiar with Microsoft Windows applications will be able to use the FluidArchitect.

### FluidArchitect User Requirements

Users of the FluidArchitect design automation application should have the following requirements:

- A good understanding and previous experience with microfluidics
- Experience with computer aided design applications



[illegible]

The following are the system requirements for installing FluidArchitect onto a PC.

- FluidArchitect is delivered as an installation package to be executed on the target PC it is to be installed onto. The installation package will automatically guide you through the installation process step by step. All files and libraries will be installed into a directory that can be specified by you.

Once you have successfully installed the program onto your computer you will need to request a license to unlock the FluidArchitect application in order to use it. The unlock code that will be generated is specifically for the computer the application is installed on. Follow the steps outlined below to request a license for your copy of FluidArchitect.

- 6





- | Table 1. Demographic characteristics of the study population |             |
|--|-------------|
| Age (years)  | Mean (SD)   |
| Male   | 55.2 (10.5) |
| Female   | 56.8 (11.2) |
| Marital status   |             |
| Married  | 78.5%       |
| Single   | 21.5%       |
| Education level  |             |
| High school or less  | 65.2%       |
| College or more  | 34.8%       |
| Occupation   |             |
| Professional   | 25.1%       |
| Managerial   | 18.7%       |
| Technical  | 12.3%       |
| Service  | 31.5%       |
| Unemployed   | 12.4%       |
| Income (USD/month)   |             |
| < 1000   | 15.2%       |
| 1000-2000  | 32.1%       |
| 2000-3000  | 28.5%       |
| > 3000   | 24.2%       |

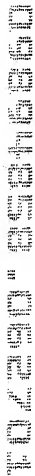


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| 2000-3000  | 28.5%       |
| > 3000   | 24.2%       |



## Chapter 2 – Design Process

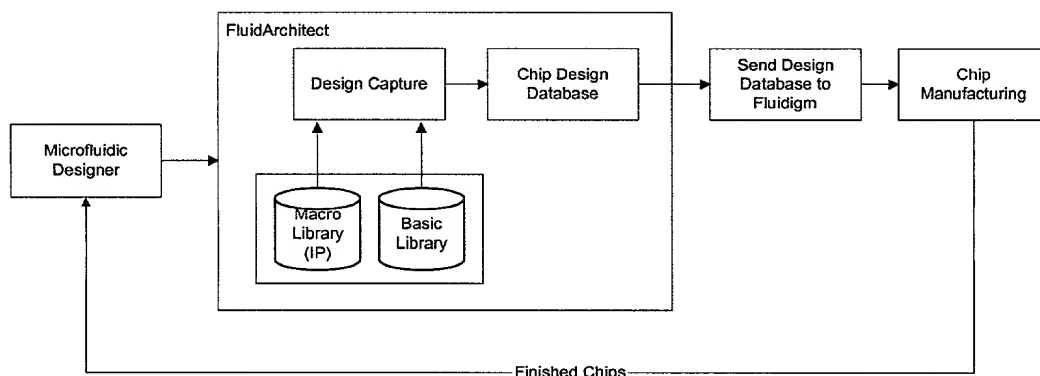


Figure 3 – Microfluidic Chip Design Process with FluidArchitect

### Design Flow Process

The design process for designing and building a microfluidic chip is described in Figure 1. Application specific microfluidic chips can be created using the library components provided by Fluidigm. FluidArchitect allows you to capture your design in a simple drag and drop, point and click design environment. Once the design has been completed it is sent to Fluidigm for fabrication. Fabricated devices are sent back to the microfluidic designer for use.

### Application Interface

FluidArchitect's interface contains the entire environment in which a design will be started and completed for submission to Fluidigm for fabrication.

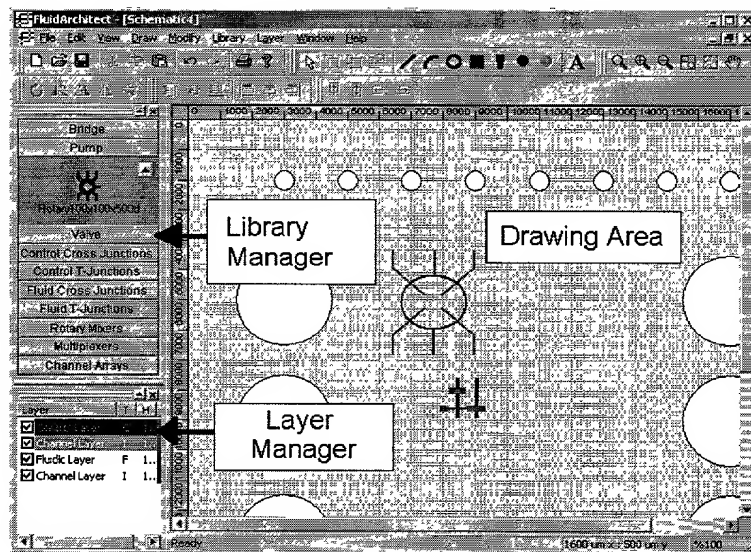


Figure 4 – FluidArchitect's User Interface

The user interface has three primary components: *Library Manager*, *Layer Manager*, and *Drawing Area* (see Figure 4).

#### *Library Manager*

The component libraries come predefined and are installed with the FluidArchitect application. The library components are tested and approved for use in the microfluidic chip making process. These libraries will be updated with new components as they are approved from Fluidigm for use. The component library will be delivered as part of a new release or



# Submitting a Design Database for Fabrication

Once the design has been completed and verified free of errors it can be submitted to Fluidigm for fabrication. The design database can be found in the directory that the design was created in. The file extension of the design database is \*.mdx. This file can be sent to [manufacturing@fluidigm.com](mailto:manufacturing@fluidigm.com) along with your contact information. A representative from Fluidigm will contact you regarding the details of your order for fabrication.

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# Chapter 3 – Design Editor Reference

## Introduction

The goal of the design editor is to help you design effectively and as efficiently as possible. The libraries that are built into FluidArchitect represent microfluidic structures that are approved for implementation in Fluidigm’s processes. “Channel” drawing tools are provided to connect the microfluidic structures available from the libraries. The sections below will described the design editor in detail.

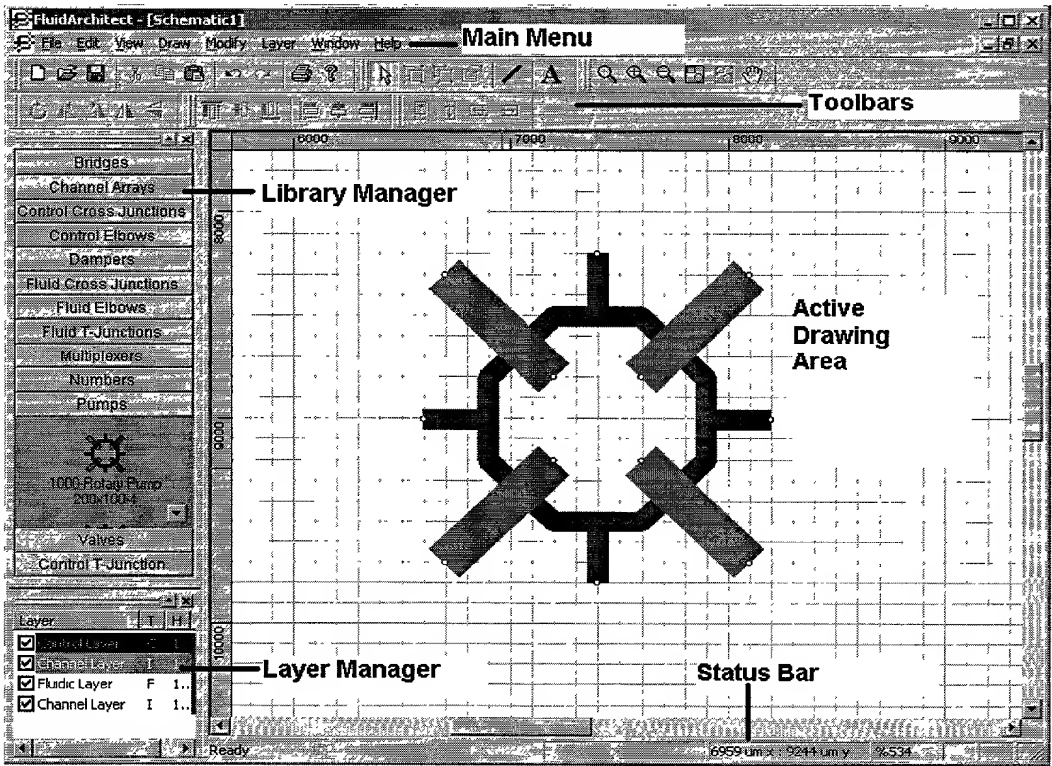


Figure 5 – FluidArchitect Main User Interface (Main Menu, Toolbars, Library Manager, Layer Manager, and Active Drawing Area)

## Menus

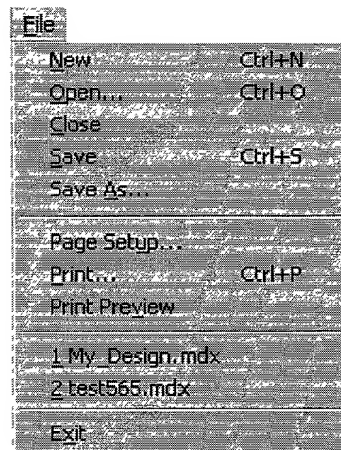
### Main Menu

The main menu is composed of nine menu groups which group related operations and commands for the application.



Figure 6 – Main Menu Bar

Table 1. Demographic characteristics of the study population	
Age (years)	65.0 ± 1.5
Gender	
Male	50 (50.0%)
Female	50 (50.0%)
Education (years)	12.0 ± 1.0
Marital status	
Married	40 (80.0%)
Single	10 (20.0%)
Occupation	
Retired	30 (60.0%)
Unemployed	20 (40.0%)
Income (USD/month)	1000.0 ± 200.0
Health status	
Good	30 (60.0%)
Poor	20 (40.0%)
Smoking status	
Smoker	10 (20.0%)
Non-smoker	40 (80.0%)
Alcohol consumption	
Drinker	5 (10.0%)
Non-drinker	45 (90.0%)
Comorbidities	
Hypertension	15 (30.0%)
Diabetes	10 (20.0%)
Cholesterol	12 (24.0%)
Arthritis	8 (16.0%)
Depression	5 (10.0%)
Other	3 (6.0%)



### Figure 7 – File Menu Commands

**File > New**

The *New* command starts the Design Wizard which will automatically set up the design project. (see *Creating a Design* for more details on the Design Wizard).

**File > Open...**

The *Open* command opens an existing design which has been saved.

**File > Close**

The *Close* command closes the active design project in the application. Closing a design project will safely close and exit the application. If any changes were made to the active design, you will be asked whether or not you want to continue to close the design.

**File > Save**

The **Save** command saves the active design project in the application. Saving the design will save the design project and close the project.

**File > Save As...**

The **Save As...** command saves the active design project in the application. This command allows you to save the design project under a different name or directory location other than the current location where the file is saved.

*File > Page Setup*

The *Page Setup* command allows you to set the print options for the active design project.

*File > Print*

The *Print* command will print the active design project and scale the design to fit the selected Paper size for the Printer.

## File &gt; Print Preview

The *Print Preview* command will preview a print of the active design project to the screen.

Table 1. Demographic characteristics of the study population	
Age (years)	65.5 ± 10.5
Gender (male/female)	10/10
Education (years)	12.5 ± 2.5
Occupation (white/blue)	10/10
Marital status (married/divorced/widowed)	10/10/0
Smoking status (smoker/nonsmoker)	10/10
Alcohol consumption (yes/no)	10/10
Comorbidities (hypertension/diabetes/cholesterol)	10/10/10
Medication (antihypertensive/antidiabetic/anticholesterol)	10/10/10
Family history (hypertension/diabetes/cholesterol)	10/10/10
Physical activity (yes/no)	10/10
Stress level (low/moderate/high)	10/10/10
Sleep quality (good/poor)	10/10
Depression score (0-10)	2.5 ± 1.5
Overall health status (good/fair/poor)	10/10/10

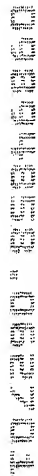


Table 1. Demographic characteristics of the study population	
Age (years)	65.5 ± 10.5
Gender (male/female)	10/10
Education (years)	12.5 ± 2.5
Occupation (white/blue)	10/10
Marital status (married/divorced/widowed)	10/10/0
Smoking status (smoker/nonsmoker)	10/10
Alcohol consumption (yes/no)	10/10
Comorbidities (hypertension/diabetes/cholesterol)	10/10/10
Medication (antihypertensive/antidiabetic/anticholesterol)	10/10/10
Family history (hypertension/diabetes/cholesterol)	10/10/10
Physical activity (yes/no)	10/10
Stress level (low/moderate/high)	10/10/10
Sleep quality (good/poor)	10/10
Depression score (0-10)	2.5 ± 1.5
Overall health status (good/fair/poor)	10/10/10

Table 1. Demographic characteristics of the study population	
Age (years)	65.5 ± 10.5
Gender (male/female)	10/10
Education (years)	12.5 ± 2.5
Occupation (white/blue)	10/10
Marital status (married/divorced/widowed)	10/10/0
Smoking status (smoker/nonsmoker)	10/10
Alcohol consumption (yes/no)	10/10
Comorbidities (hypertension/diabetes/cholesterol)	10/10/10
Medication (antihypertensive/antidiabetic/anticholesterol)	10/10/10
Family history (hypertension/diabetes/cholesterol)	10/10/10
Physical activity (yes/no)	10/10
Stress level (low/moderate/high)	10/10/10
Sleep quality (good/poor)	10/10
Depression score (0-10)	2.5 ± 1.5
Overall health status (good/fair/poor)	10/10/10

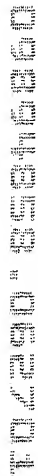
[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]



Figure 9 – Component Dialog Box

Additional commands available from this dialog box are:

- *OK* – Closes the dialog box
- *Go To* – Not currently implemented
- *Properties* – Opens the Properties dialog sheet for the component
- *Delete* – Not currently implemented

#### **Edit > Default Properties**

The *Default Properties* command will bring up the Properties dialog box for the entire design. The dialog box, Figure 6, will show all of the default settings for the design

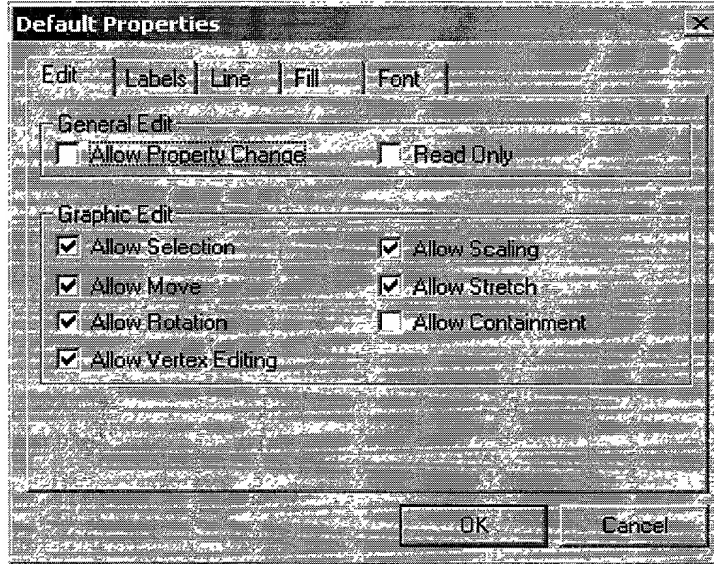


Figure 10 – Default Properties Dialog Box

- *OK* – Closes the dialog box and save any changes
- *Cancel* – Closes the dialog box and discards changes
- *Edit tab* – Not currently implemented
- *Labels* – Sets the label orientation for components
- *Line* – Not currently implemented
- *Fill* – Not currently implemented
- *Font* – Sets the fonts options for the labels

# View Menu

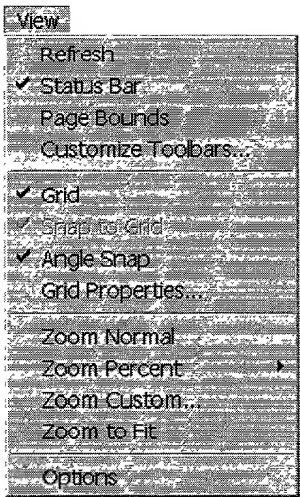


Figure 11 – View Menu Commands

## View > Refresh

The *Refresh* command will redraw the active drawing area. Sometimes the drawing area may not refresh completely during editing of the design leaving screen artifacts. The *Refresh* command can be used to redraw the screen to eliminate the artifacts. Note that the artifacts will not be saved into the design.

## View > Status Bar

The *Status Bar* command can be used to display or remove the status bar in the lower right corner of the application. The Status Bar, Figure 12, shows the selected component, the screen location of the cursor, and the percent zoomed.



Figure 12 – Status Bar

## View > Page Bounds

The *Page Bounds* not currently implemented.

## View > Customize Toolbars...

The *Customize Toolbars...* allow you to show or hide the toolbar tool bars in the application window directly under the Main Menu bar. Figure 13 shows the dialog box that appears when this command is selected. All of the toolbars, including the Main Menu bar, can be displayed or hidden based on settings made through this dialog box with the Toolbars tab selected.



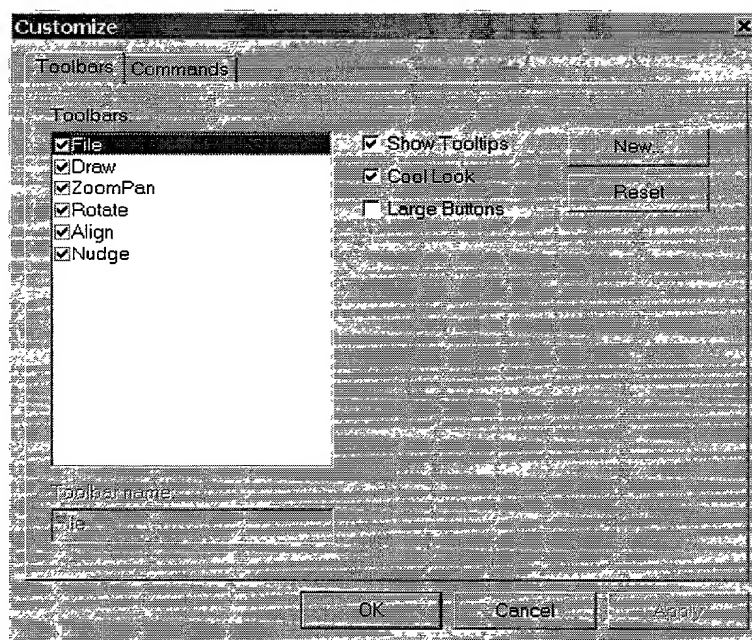


Figure 13 – Customize Toolbars Dialog Box with Toolbars tab selected

The toolbars can be customized by dragging and dropping commands icons from the dialog box directly into the existing toolbars present in the application. Figure 14 shows the “Buttons” or commands that can be left click and dragged to the toolbars.

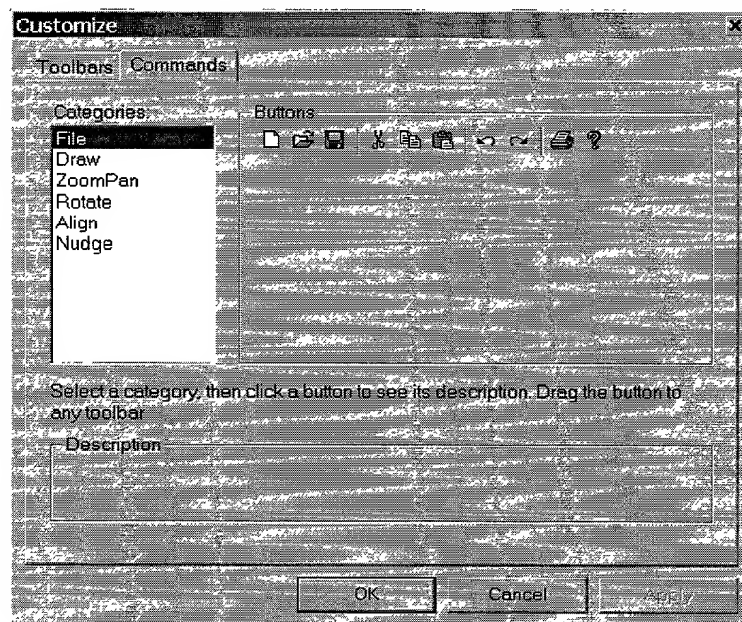


Figure 14 – Customized Toolbars Dialog Box with Commands tab selected

#### View > Grid

The *Grid* command enables or disables the grid to be displayed in the active drawing area.

### View > Grid Properties...

The *Grid Properties...* command will bring up the dialog box, Figure 15. The Grid dialog box allows you to set the grid color and the intervals at which the grid is rendered and also to enable or disable the grid from the drawing area.

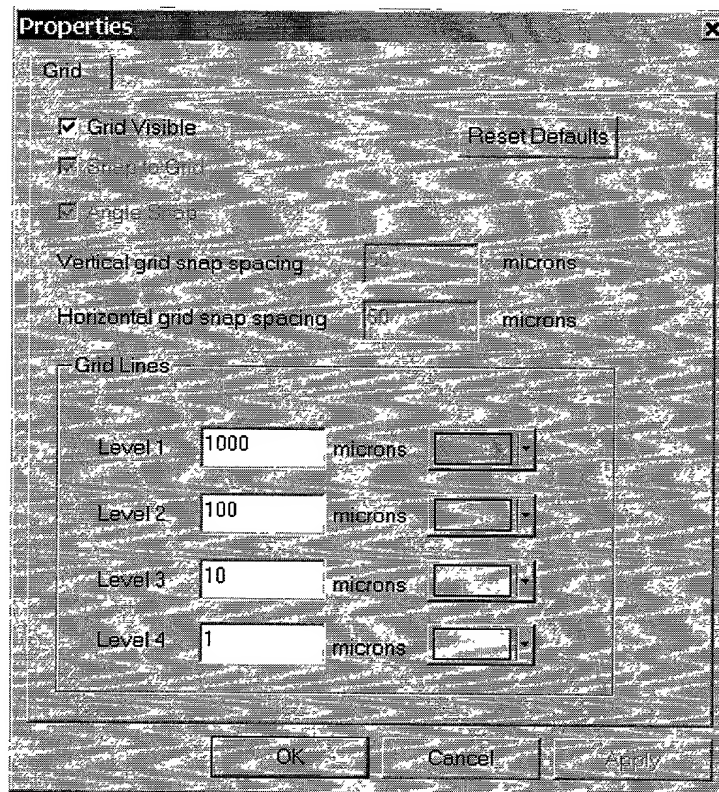


Figure 15 – Grid Properties Dialog Box

### View > Zoom Normal

The *Zoom Normal* command will zoom the view of the active drawing area to view the entire chip.

### View > Zoom Percent

The *Zoom Percent* command allows you to select 50%, 75%, 100%, and 200% zoom of the active drawing area.

### View > Zoom Custom...

The *Zoom Custom...* command allows you to select 50%, 75%, 100%, and 200% from the drop down box and you can also enter in your own zoom factor of the active drawing area.

### View > Zoom Fit

The *Zoom Fit* command will zoom the view of the active drawing area to view the entire chip.

### View > Options

The *Options* command will bring up the *Grid* and *Library* dialog box, Figure 16. The Grid properties are the same as those in the *View > Grid Properties...*

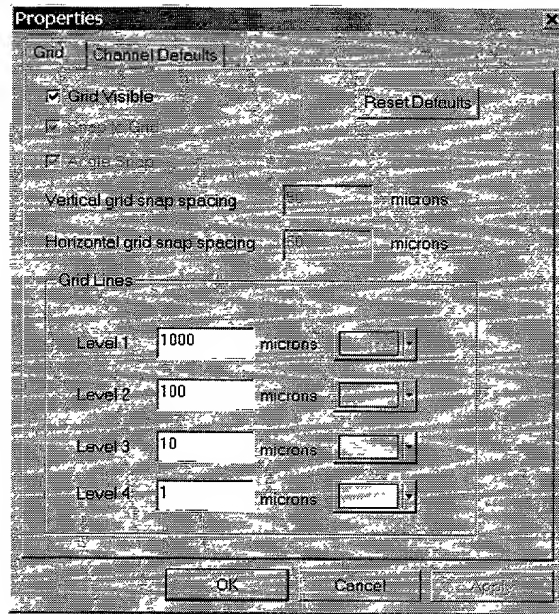


Figure 16 – Grid and Channel Defaults Dialog Box

The Channel Defaults allow you to set the default channel widths for the fluidic and the control layer channels that are drawn to interconnect the library components. Figure 17 shows the dialog box with the Channel Defaults tab selected.

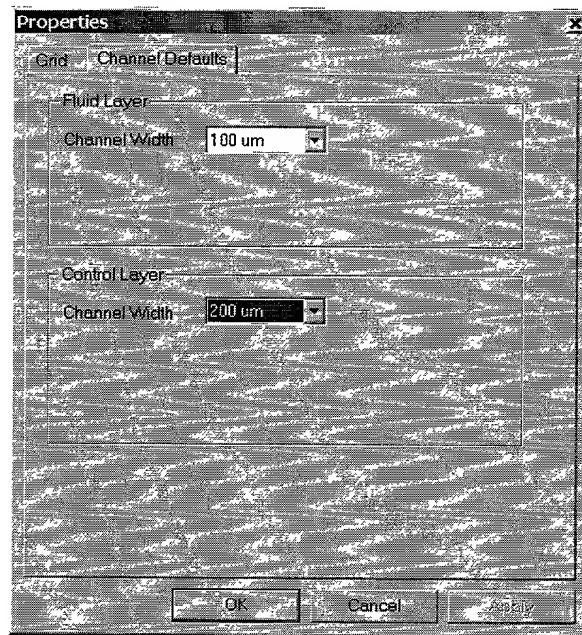


Figure 17 – Channel Defaults Selection Dialog Box

The drop down boxes allow you to set the default width of the channel that you draw on both the fluidic and control layer. Keep in mind that any drawn channel's width can be changed using the Property sheet for each channel.

# Draw Menu



Figure 18 – Draw Dialog Box

## Draw > Channel

The *Channel* command places the mode of the active drawing area into drawing channels. A drawn channel will be to the layer that is currently “Active”. A layer can be set active in two methods: enabling the layer to be active through the *Library Manager*, Figure 12, or through a right mouse click while in the active drawing area with the *Select* tool selected. Select the *Layers* command to set the desired layer, Figure 19.

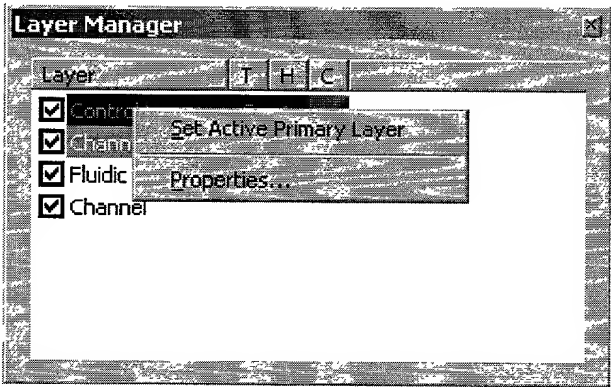


Figure 19 – Library Manager Window

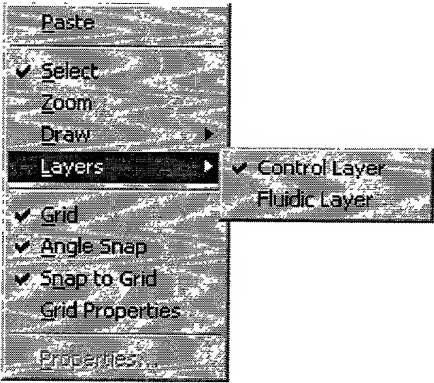


Figure 20 – Right Click Pop Up Menu in Drawing Area

# Modify Menu

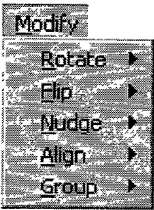


Figure 21 – Modify Menu Commands




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*Modify > Rotate > Free*

*Modify > Rotate > Right*

*Modify > Rotate > Left*

## Modify > Flip



*Modify > Flip > Horizontal*

*Modify > Flip > Vertical*

## Modify > Nudge

Modify

- Rotate
- Flip
- Nudge
  - Down
  - Up
  - Left
  - Right
- Align
- Group

**■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■**

*Modify > Nudge > Down*

The *Down* command allows you to move the selected object(s) down one micron in the active drawing area. Holding the Shift key while executing this command will move the object 5 microns.

*Modify > Nudge > Up*

The *Up* command allows you to move the selected object(s) up one micron in the active drawing area. Holding the Shift key while executing this command will move the object 5 microns.

*Modify > Nudge > Left*

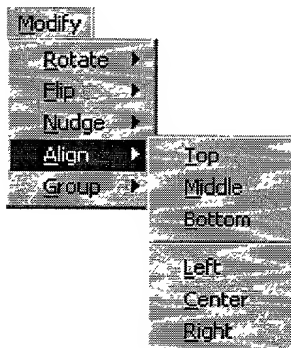
The *Left* command allows you to move the selected object(s) left one micron in the active drawing area. Holding the Shift key while executing this command will move the object 5 microns.

*Modify > Nudge > Right*

The *Right* command allows you to move the selected object(s) right one micron in the active drawing area. Holding the Shift key while executing this command will move the object 5 microns.

## Modify > Align

The *Align* command contains a submenu of commands, Figure 25, which can be performed on a selected object(s) in the active drawing area.



### Figure 25 – Align Submenu Commands

*Modify > Align > Top*

The *Top* command allows you to select a group of objects in the active drawing area and have the top of the objects aligned together.

*Modify > Align > Middle*

The *Middle* command allows you to select a group of objects in the active drawing area and have all of the objects aligned to horizontal middle.

*Modify > Align > Bottom*

The *Bottom* command allows you to select a group of objects in the active drawing area and have the bottom of the objects aligned together.

*Modify > Align > Left*

The **Left** command allows you to select a group of objects in the active drawing area and have all of the objects aligned to the left.

*Modify > Align > Center*

The **Center** command allows you to select a group of objects in the active drawing area and have all of the objects aligned to vertical center.





*Modify > Align > Right*

The *Right* command allows you to select a group of objects in the active drawing area and have all of the objects aligned to the right.

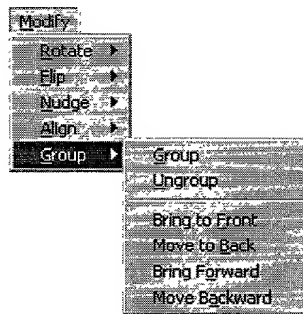


Figure 26 – Group Submenu Commands

*Modify > Group*

The *Group* command allows you to select a group of objects in the active drawing area and group the objects into a single entity or the ability to select a grouped object and ungroup them into their original components.

*Modify > Group > Group*

The *Group* command allows you to select a group of objects in the active drawing area and group the objects into a single entity.

*Modify > Group > Ungroup*

The *Group* command allows you to select a grouped object in the active drawing area and ungroup the objects back to their stand alone state.

*Modify > Group > Bring to Front*

Not Currently Implemented

*Modify > Group > Move to Back*

Not Currently Implemented

*Modify > Group > Bring Forward*

Not Currently Implemented

*Modify > Group > Move Backward*

Not Currently Implemented



Table 1. Demographic characteristics of the study population	
Age (years)	65.8 ± 1.2
Gender (male/female)	10/10
Education (years)	12.5 ± 0.5
Occupation (white/blue)	10/10
Marital status (married/divorced/widowed)	10/10/0
Smoking status (smoker/nonsmoker)	10/10
Alcohol consumption (yes/no)	10/10
Comorbidities (hypertension/diabetes/cholesterol)	10/10/10
Medication (antihypertensive/antidiabetic/anticholesterol)	10/10/10
Family history (hypertension/diabetes/cholesterol)	10/10/10
Physical activity (yes/no)	10/10
Stress level (low/moderate/high)	10/10/10
Sleep quality (good/poor)	10/10
Depression score (0-10)	2.5 ± 0.5
Anxiety score (0-10)	3.0 ± 0.5
Life satisfaction score (0-10)	7.5 ± 0.5
Health-related quality of life score (0-10)	6.5 ± 0.5
Overall health status (good/fair/poor)	10/10/10
Duration of study (months)	12 ± 0.5
Dropouts (yes/no)	0/10
Adherence to protocol (yes/no)	10/10
Consent to participate (yes/no)	10/10
Eligibility criteria (met/not met)	10/10
Randomization (yes/no)	10/10
Blinding (yes/no)	10/10
Statistical analysis (yes/no)	10/10
Publication (yes/no)	10/10
Archiving (yes/no)	10/10
Reproducibility (yes/no)	10/10
Validity (yes/no)	10/10
Reliability (yes/no)	10/10
Generalizability (yes/no)	10/10
Applicability (yes/no)	10/10
Feasibility (yes/no)	10/10
Ethical approval (yes/no)	10/10
IRB approval (yes/no)	10/10
Registration (yes/no)	10/10
Peer review (yes/no)	10/10
Open access (yes/no)	10/10
Supplementary material (yes/no)	10/10
Conflict of interest (yes/no)	10/10
Funding source (yes/no)	10/10
Author contribution (yes/no)	10/10
Correspondence (yes/no)	10/10
References (yes/no)	10/10
Tables (yes/no)	10/10
Figures (yes/no)	10/10
Appendices (yes/no)	10/10
Supplementary tables (yes/no)	10/10
Supplementary figures (yes/no)	10/10
Supplementary text (yes/no)	10/10
Supplementary references (yes/no)	10/10
Supplementary appendices (yes/no)	10/10
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Supplementary appendices (yes/no)	10/10
Supplementary tables (yes/no)	10/10
Supplementary figures (yes/no)	10/10
Supplementary text (yes/no)	10/10
Supplementary references (yes/no)	10/10
Supplementary appendices (yes/no)	



The *Layer Manager* command brings up the Layer Manager dialog box as shown in Figure 27.



The *Primary Layers* section of the dialog box shown in Figure 28 shows the total number of layers present in the design. Currently it is not possible to change the *Name* nor the *Depth* of these primary layers. You can change the color of the layers in the *Properties* section of the dialog box once the primary layer is selected. Click on the *Apply* button after any changes are made to save the changes.

The *Channel Layers* section of the dialog box shown in Figure 28 shows the total number of channel depths available in one primary layer. Currently this is set to one channel depth per primary layer. You can change the name of the channel layer by left clicking on the layer name to select it in the Channel Layers section of the dialog and then entering in a new name in the *Properties* section. Click on the *Apply* button after any changes are made to save the changes. Also note that the channel depth is shown for the layer once it has been selected.









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Use of the Library Manager is simple and straightforward. To select the library desired, simply left click on the title of the library and the components will be displayed. If more than one component is present in the library use the up or down button to scroll through them.



### Library Component Characteristics

A library component is typically composed of channels. Some components have channels only on one layer while some have channels on both layers. Figure 37 shows a microfluidic valve from the Valves library.



**Note:** Channel or component connections to connection ports of components **MUST** be members of the same layer.



## Layer Manager

The Layer Manager serves to indicate the coloring of the layers as well as the different channel heights that are available in the particular layer. Currently only two layers are available at this time. The Layer Manager can be used to select the “Active” layer such that any drawn channels are added to that layer, change the coloring of the layer, and display or hide a layer from the active drawing area.

Figure 38 shows the Layer Manager window and the highlights the information available from the Layer Manager window.

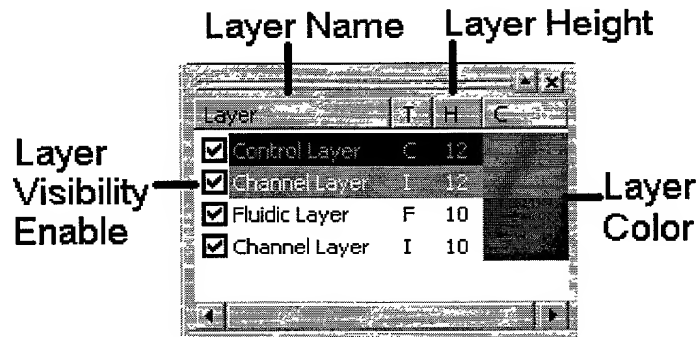


Figure 38 – Layer Manager

### Layer Color

The default layer color is blue for the fluidic layer and red for the control layer. These colors can be changed to suit your preference.

### Setting the Active Primary Layer

As mentioned above, the “Active Primary Layer” can be set through the Library Manager. Figure 39 shows the pop up after selecting the *Control* or *Fluidic* layer by left clicking to select it in the Layer Manager. Once selected, right clicking will bring up a pop up dialog box allowing you the ability to set the layer to be active.

Setting the layer to be active enables the following:

- Drawing of channels onto that layer.
- Selecting channels or components that are on that layer and performing actions on those selected.
- Changing the color of the layer. Any new color selected will replace the existing color for all components and channels in that layer.

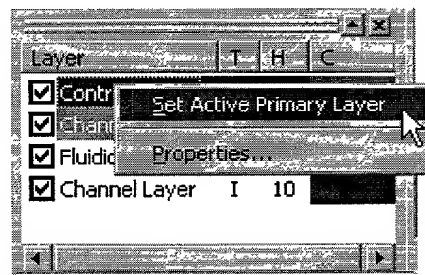
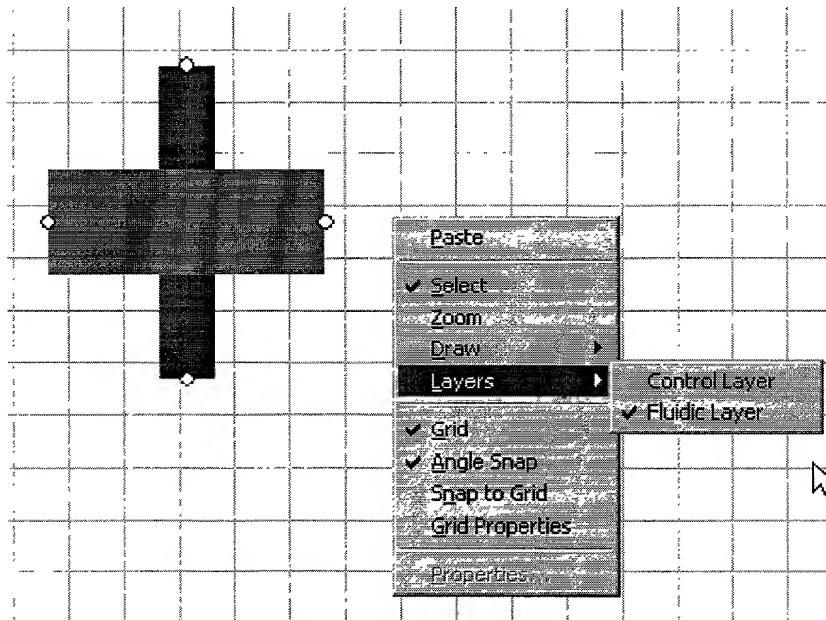


Figure 39 – Setting the Active Primary Layer

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2
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Select tool (  ) enabled Pop Up Menu

The pop up menu contains some of the most frequently used commands from the tool bar with the addition of the *Layers* command. The *Layers* command can be used to set active the layer you need to draw on without having to go to the Layer Manager. Figure 41 shows the submenu to select and set active a layer.



### Figure 42 – Layer Submenu Selection

The check mark next to the layer name indicates the layer that is currently selected.

### Selected Component/Channel Pop Up Menu

Once a component(s) or channel(s) is selected in active drawing area, a right click will pop up a menu to allow functions or commands to be performed on the selected objects.. The pop up menu is context sensitive in that a selected component will bring up a different pop up menu as opposed to a selected channel. Figure 43 shows a component selected and the pop

commands available. The function descriptions can be found in the Main Menu or Toolbar commands with the exception of the *Properties...* command

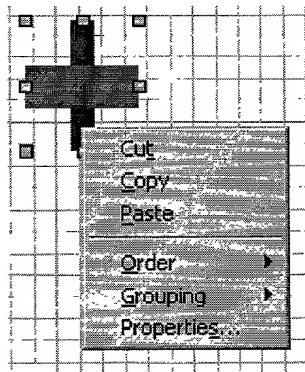


Figure 43 – Selected Component Pop Up Menu

Figure 44 shows a channel selected and the pop up menu with its available commands. Notice here the addition of the *Channel Widths* command. The Channel Widths command allows quick modifications of the drawn channels so that matching to connected components or channels is easily facilitated. Figure X shows an example where a channel drawn at 50  $\mu\text{m}$  needs to be connected to a pump control element that is 200  $\mu\text{m}$  in width.

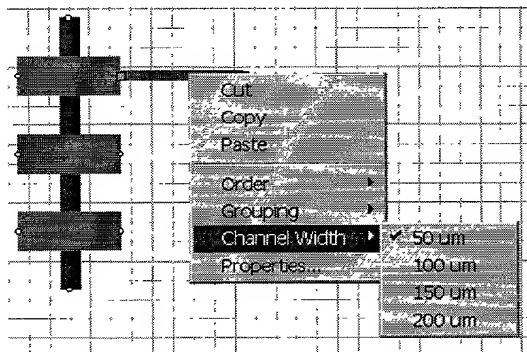


Figure 44 – Selected Channel Pop Up Menu

## Status Bar

The Status Bar has two modes. One mode is when the drawing area is in the *Select* mode and the other is in the channel drawing mode.

### Select Mode

In the *Select* mode the status bar contains the following information:

- Left Status Box: Component Name
- Center Status Box: Absolute Cursor Location (in microns)
- Right Status Box: Percentage Zoomed In

Figure 45 shows the Status Bar while in the select mode.

Figure 45 – Status Bar in Select Mode

In the *Drawing* mode the status bar contains the following information:

- Figure 46 shows the Status Bar while in the select mode. Notice as you start drawing the channel the status bar is updated with the length of the channel drawn.



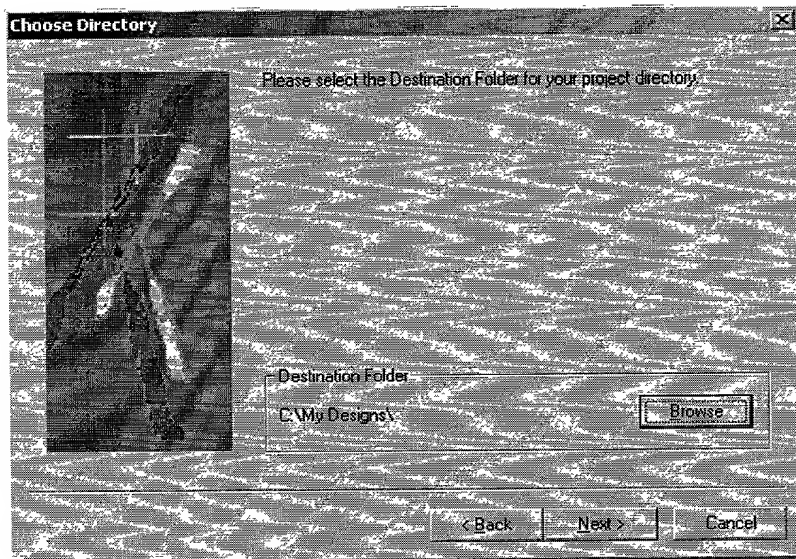
[illegible]

FluidArchitect was built with many design rules that are implemented directly into the various parts of the design system. As such, FluidArchitect applies those design rules to your design as you are placing and connecting the components from the libraries in the drawing area. The following are general rules to keep in mind and will help lead to a successful design implementation.

- **Only library components delivered by Fluidigm can be used in a design.**
- **Do not overlap components.** All components should be connected to other channels or other components via port connections. (see *Connecting Components and Channels*)
- **Do not overlap channels.** Channels on the same layer or channels on different layers cannot be overlapped. User drawn channels must be used to connect other channels and components.
- **Only connect channels on the same layer and of the same width.** The set of components provided can be interconnected using the Channel tool. Depending on the layer, Fluidic or Control, a choice of channel widths is provided. Be sure to select the proper width for your connection.
- **Use common sense for placement of components.** Some components require more connections than others. Plan your design carefully so that you are not route restricted to where your components cannot be connected to due to other connection requirements.

The Design Wizard walks you through the setup of the design and will allow you to set up the following details of your design:

- [illegible]



**Figure 48 – Design Directory Selection Wizard Screen**

- **Chip Template Selection**  
The appropriate chip template can be selected from this wizard screen, see Figure 49. As you click the *< Previous* and *Next >* buttons a thumbnail of the template will appear. Notice that the solid black circles represent where inputs and outputs will be placed and the number of each particular input and output size is shown to the right of the thumbnails. Currently, once you have selected a template it is not possible to change during your design process

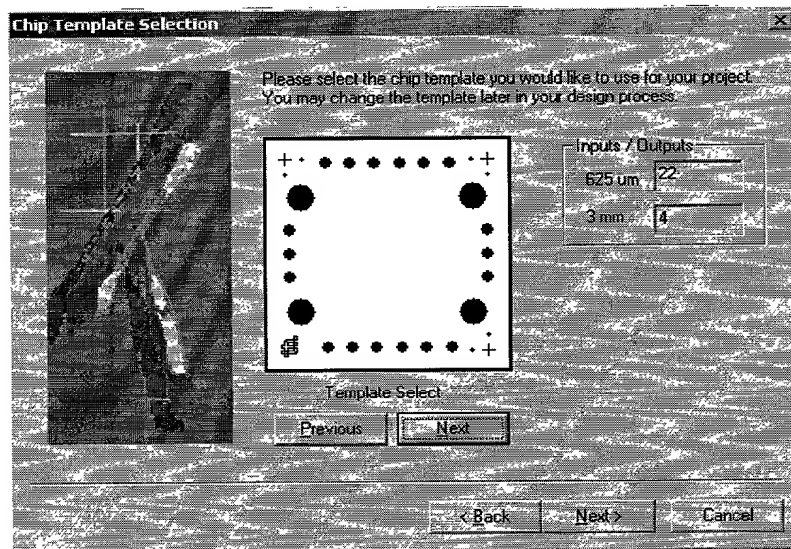


Figure 49 – Chip Template Selection Wizard Screen

- **Layer Selection**  
The layer selection screen, Figure 50, shows the number of layers that are available for use. The default is a pair of layers composed of the *Control Layer* and the *Fluidic Layer*. You can choose to deselect the layer by left clicking on the check box next to the layer name and the layer will be removed from the design. Note that after removal of this layer, active components will not be possible.



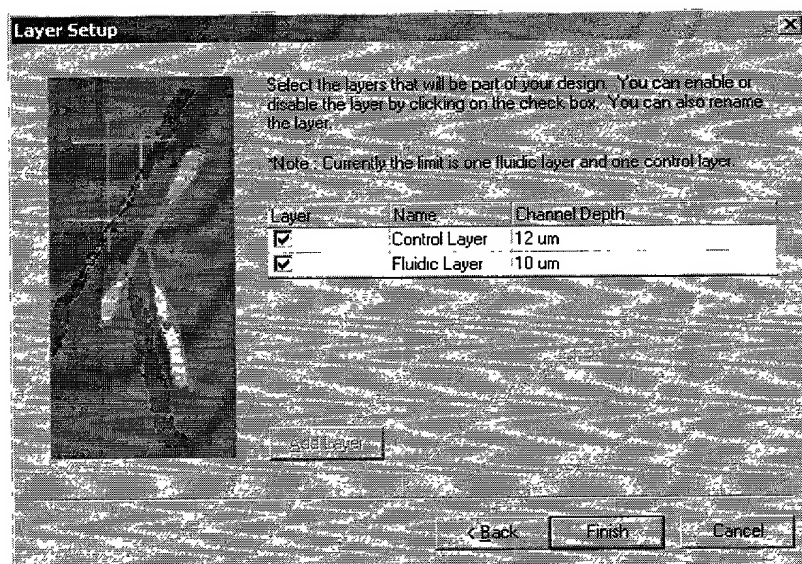


Figure 50 – Layer Selection Wizard Screen



## Placing Library Components

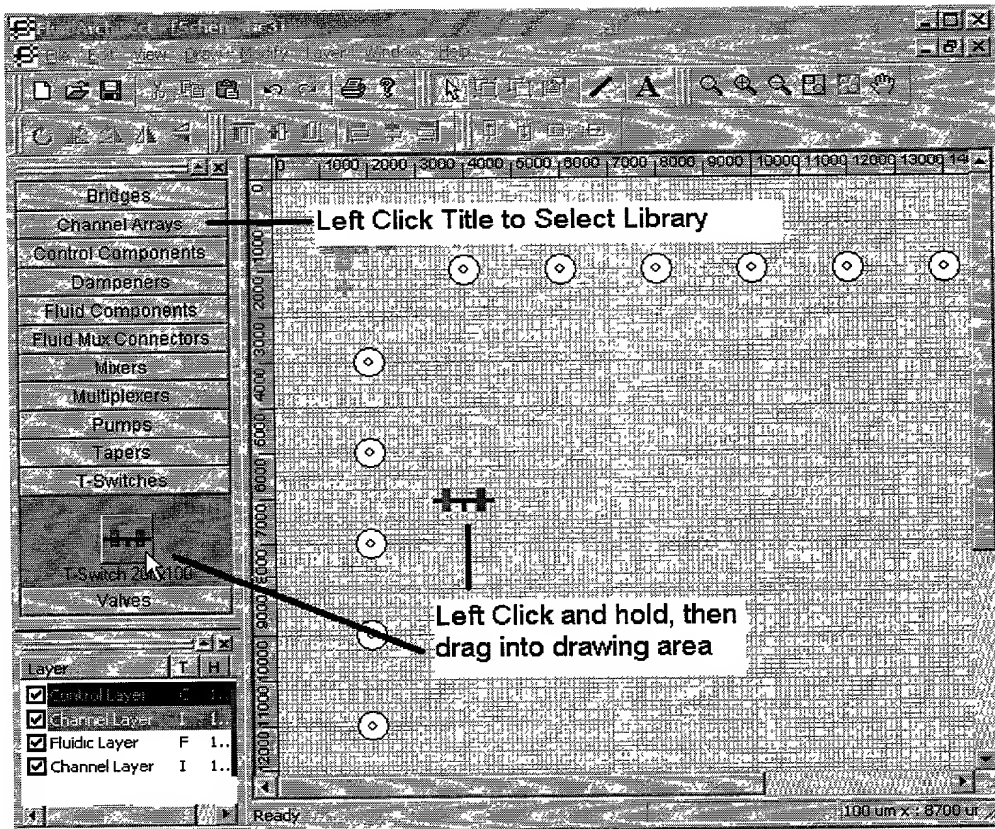


Figure 51 – Placing Components from the Libraries

The library contains a set of components that can be used in your design. Placement of the components accomplished by the following:

- Select the desired library by left clicking the mouse on the title of the library.
- Place the mouse over the desired component in the library window. The component will become selected and outlined.
- Left click and hold the mouse on the selected component and drag the component into the drawing area.
- Position the component where you would like to place it and release the left mouse button. The component will now be placed.

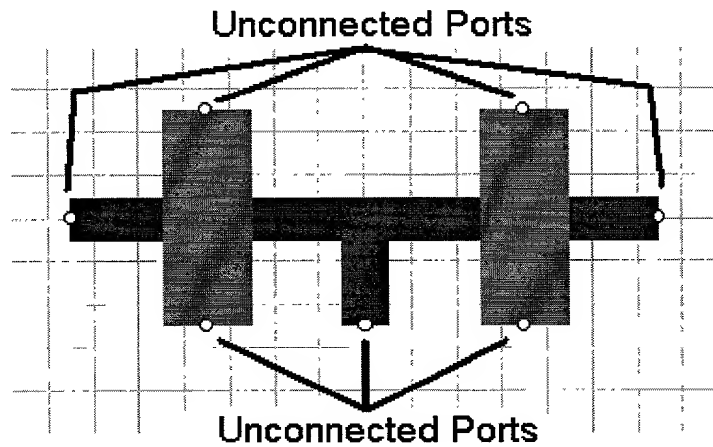
Figure 51 shows the process of placing the component from the library into the drawing area.

Note that the libraries provided are built specifically for use with our fabrication process. The components cannot be modified in any of its absolute dimensions. You only have control in its placement and its rotational position. If the component is rotated it should only be rotated in increments of +/- 90 degrees. Rotating using the free rotation tool can cause the component to become off grid and thus prevent it from being connected to other components or channels.

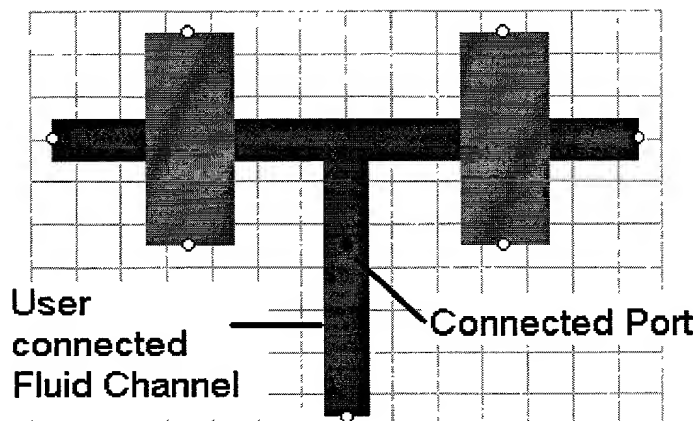
Table 1. Demographic characteristics of the study population	
Age (years)	Mean (SD)
Male	55.2 (10.5)
Female	56.8 (11.2)
Marital status	
Married	78.5%
Single	21.5%
Education level	
High school or above	65.2%
Below high school	34.8%
Occupation	
White collar	45.1%
Blue collar	54.9%
Income (USD/month)	
< 1000	12.3%
1000-2000	35.7%
2000-3000	28.9%
> 3000	23.1%
Health insurance	
Yes	89.4%
No	10.6%
Comorbidities	
Hypertension	42.1%
Diabetes	18.5%
Cholesterol	31.2%
Smoking status	
Current smoker	15.3%
Former smoker	22.7%
Non-smoker	62.0%
Alcohol consumption	
Regular	8.9%
Occasional	14.5%
Never	76.6%

## Ports of Channels and Components

- Ports are shown on components as black outlined white circles.
- Ports once successfully connected they appear as black filled circles. See Figure 53.
- Zooming in can help identify the ports on components and channels.



### Figure 52 – Ports of a Component



**Figure 53 – Fluidic Channel Connect to a Component**

## Drawing Channels

Drawing channels to connect to other channels and components can be accomplished using the Draw Channel tool. Components are built up using channels in specific placement and physical dimensions. Thus, drawing channels to connect to components is the same as connecting to other drawn channels. The following are guidelines to keep in mind while drawing channels to make connections:





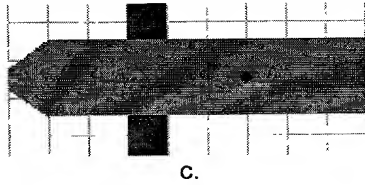


Figure 54.a Channel Port Not Detected, b. Channel Port Detected, c. Channel Connected to Port

## Input and Output Ports

The input and output ports, more commonly referred to as “I/O’s”, are the large circular figures on the template of the chip. Typically the I/O’s are found near the perimeter of the chip. The I/O’s are predetermined based on the template chosen in the Design Wizard.

I/O Ports are used to accomplish the following:

- Provide connections to fluid and material input and output from the chip.
- Provide connections to the control channels to input control signals such as air pressure.

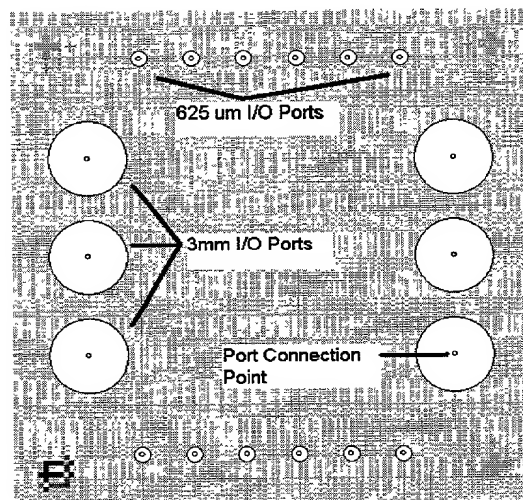


Figure 55 – Chip Template with 6 – 3mm and 12 – 625um I/O Ports

Figure 55 also shows a typical chip template with a preset I/O configuration. The connection point for each of the ports is illustrated in the figure as well. The connection point is the smaller concentric circle that is inside of the port. Connecting a channel to a port can be accomplished by drawing a channel from a channel and when the target tool is engaged over the port, double left clicking the mouse will attach the to the I/O. Once successfully connected to the I/O, the I/O will turn blue and the inner circle will become a filled black circle. Figure 56 shows a connected I/O.



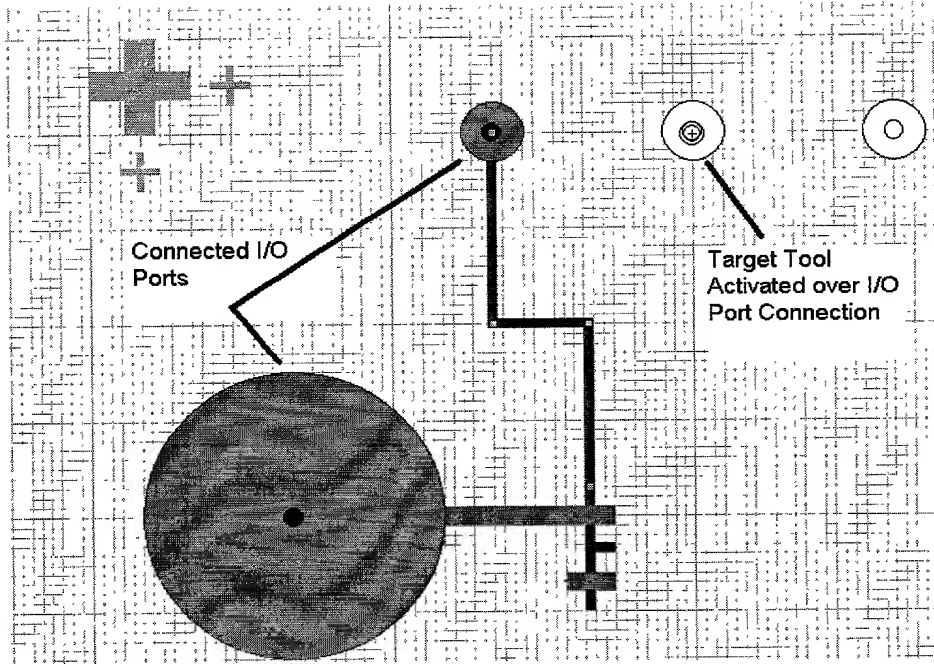


Figure 56 – Connected and Unconnected I/O Ports

## Channel Properties

Components and channels can be assigned user defined names by accessing the Properties sheet for the component or channel. Channel Properties can be used to accomplish the following:

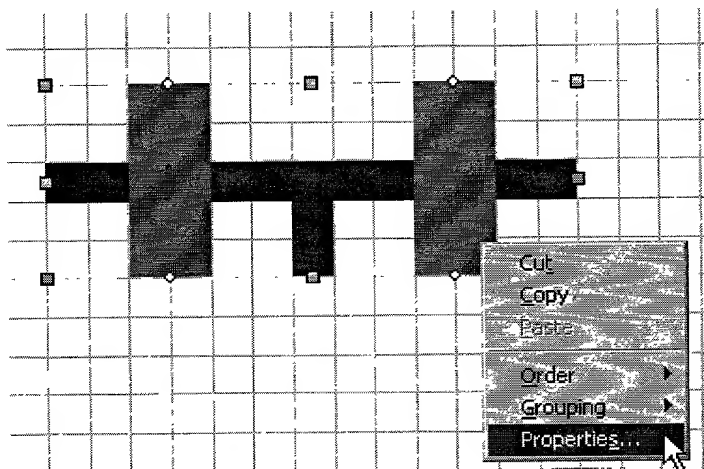
- Change Channel Instance Names
- Change Channel Widths (Fluidic and Control)
- List the connections to other components or channels

Figure 57 shows the channel dialog box for a selected control channel. You can change the width to any value in the drop down box as well as assign a new name to the channel. The channel is not currently connected to any other channel or component so the *Connections* list is empty.

## Component Properties

Figure 58 shows a selected T-Switch that was placed from the library. To bring up the Properties dialog box do the following:

- Right click on the T-Switch and select *Properties...*



**Figure 58 – Select a component and view properties**

- The Component Properties dialog box will appear. In this case, this component has been named “*My\_T-switch*”. Figure 59 shows that type of component as well as two other tabs that contains placement information regarding the component.

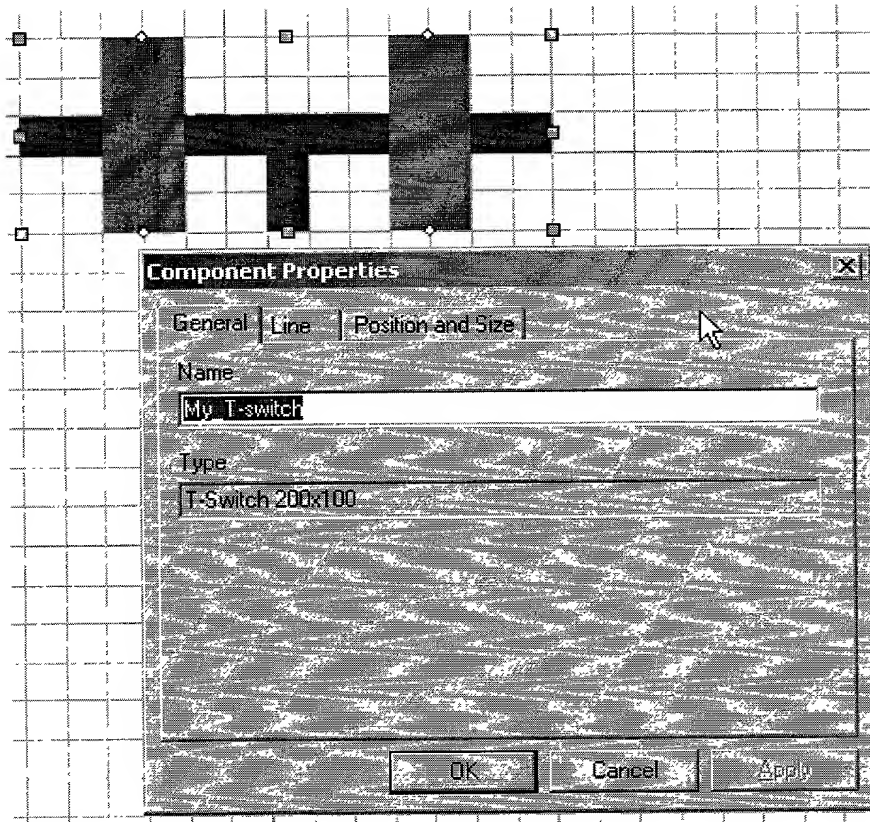


Figure 59 – Component Instance Property Dialog Box



## Design Example

In the following design example a simple cell sorter, shown in Figure 60, is created using FluidArchitect. The pump drives into a T-Switch. The T-Switch is used to drive the fluid/material flow into one of two ports based on the detection region feedback to a system, which monitors and controls the flow. The design will illustrate the methods and procedures used to create the design in FluidArchitect.

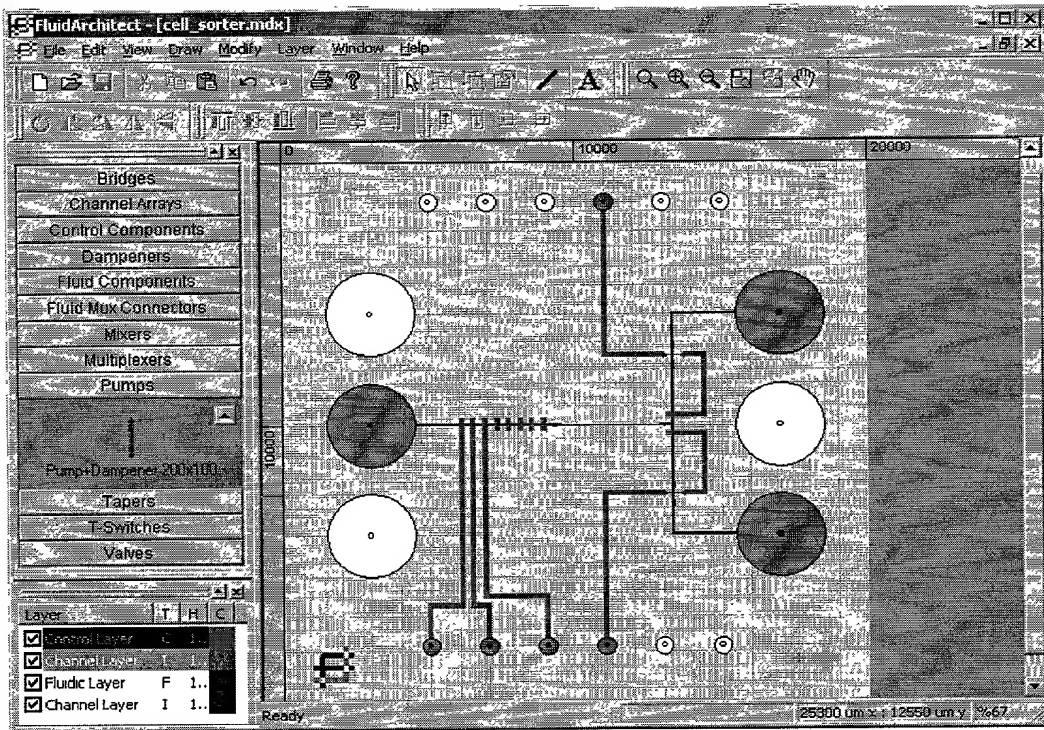


Figure 60 – Completed Design of the Simple Cell Sorter

## Components Required

The components required to construct the simple cell sorter are:

- 1 - Peristaltic Pump
- 1 - T-Sorter
- 2 – 30 um–100 um Fluidic Tapers
- 2 – Bridges
- 3 – 3 mm I/O Ports
- 5 – 625 um I/O Ports

## Basic Operation of the Design

Figure 61 shows the pump, T-Sorter, and the bridges connected in the drawing area. There are many ways to connect the components together and if the design rules are not violated the design will be valid.

Figure 61 also points out a “Detection Region”. This region can be used by an optical detection system to control the direction of the flow through the T-Sorter. The detection region is not a component from the library but rather a user drawn 30 um fluidic channel connecting fluidic taper components forming the region.

Cells are pumped through the channel from the 3mm input port on the left side of the chip using the three control valves and five damping elements that constitutes the pump. An



external detection system, such as an optical measuring system, detects cells as they flow through the “Detection Region”. The cells can be directed in either direction to the 3mm output ports by actuation of the T-sorter valve switches. The Bridge components are used to enable the crossing of fluid lines by control lines without creating a parasitic valve. The Bridge components were used in this design to create an area clear of channels for the “Detection Region”.

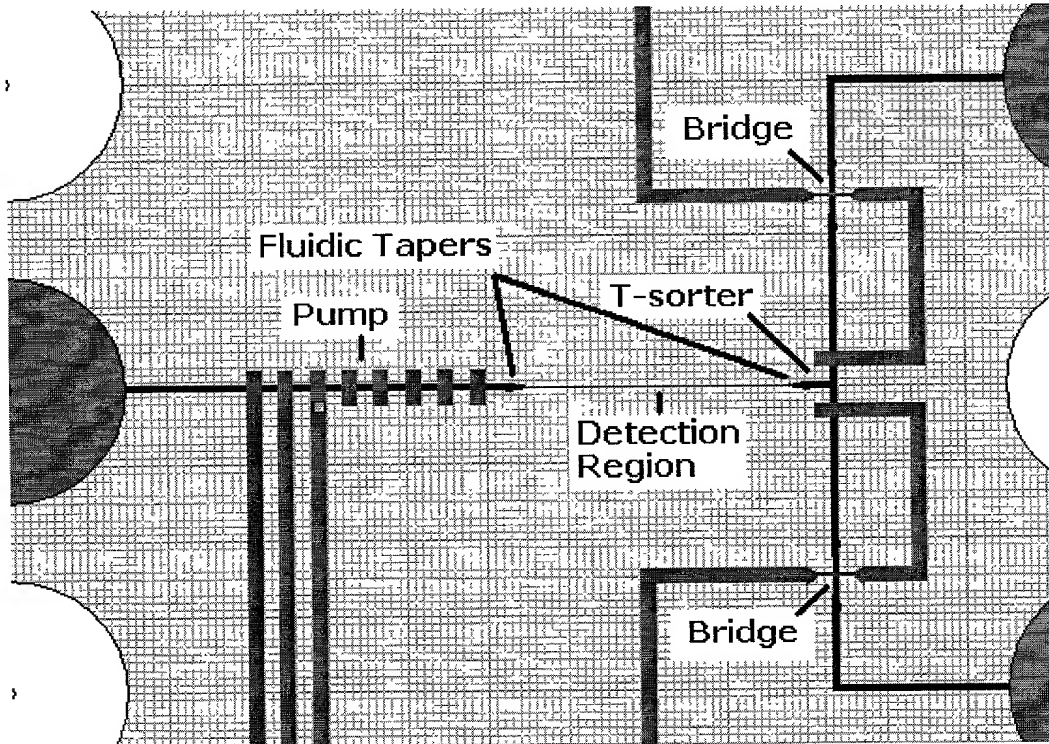


Figure 61 – Components of the Simple Cell Sorter

## Creating the Design

Start the design by launching FluidArchitect from the *Start* menu > *FluidArchitect* > *FluidArchitect* on your PC.

Once the FluidArchitect is started, the next step is to select *File* menu > *New*. The design wizard will start and guide you through the setup for a new design.

## Design Wizard Setup

The Figure 62 shows the Design Wizard screens as they appear in order querying for selections. Carefully read the screens shown by the Design Wizard to appropriately setup the design. Failure to setup the design correctly could lead to reiterations of the design to get the desired results.

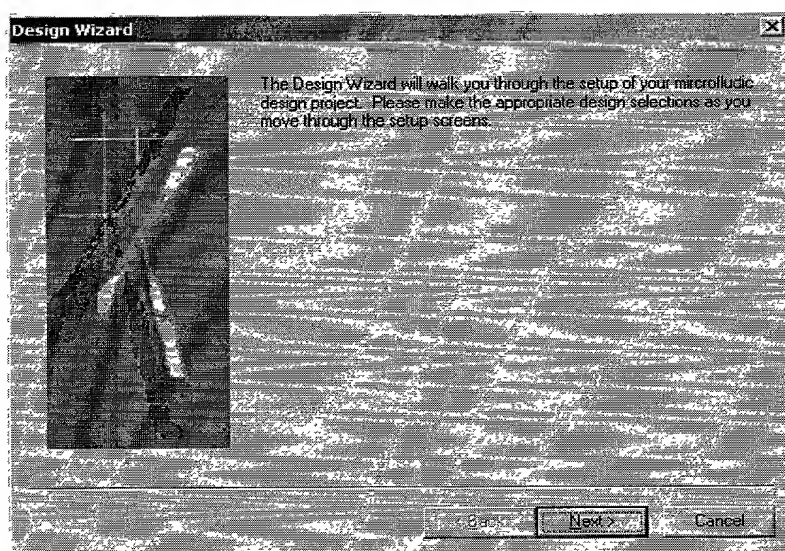


Figure 62 – First Design Wizard Screen

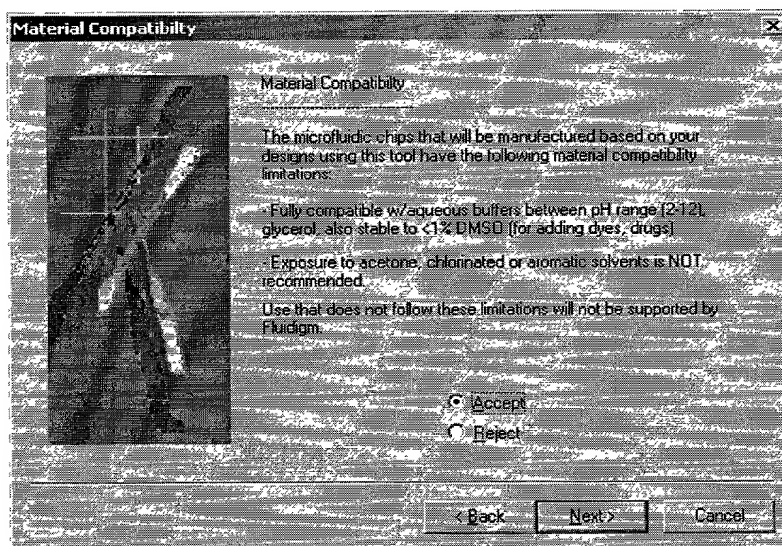


Figure 63 – Material Compatibility Design Wizard Screen

The material compatibility screen warns you to the materials that can and cannot be used with the microfluidic chips that are designed with the FluidArchitect system and fabricated by Fluidigm. Selecting “Accept” will allow you move forward with the design setup. If your needs are not met and you “Reject” the Design Wizard will not go forward. Please contact the factory for more details regarding your special needs.

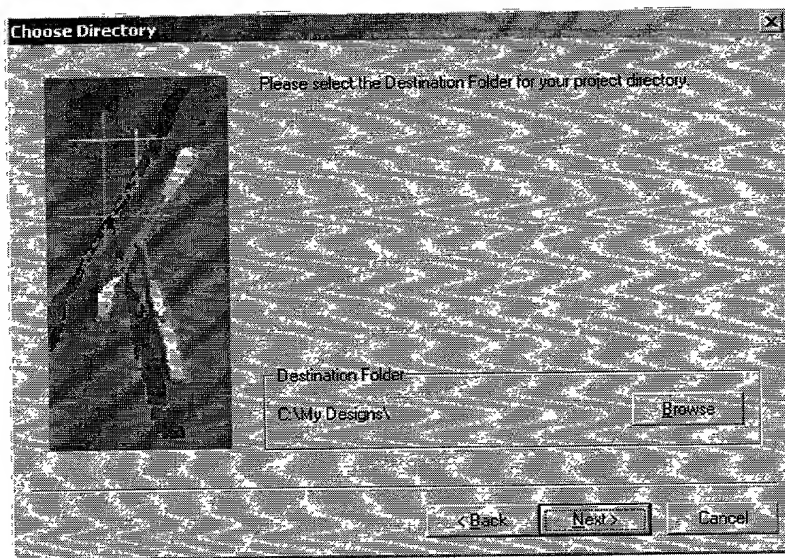


Figure 64 – Project Directory Selection

The Project Directory selection screen simply selects the directory where your design database will be stored.

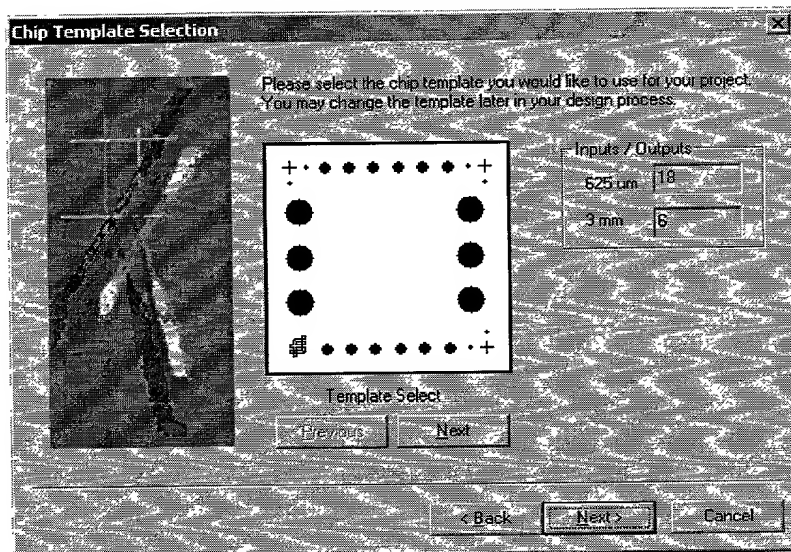


Figure 65 – Chip Template Selection

The chip template selection is very important. Please consider your design and how many inputs and outputs are needed. There are several templates to choose from and the number of 625 um and 3 mm input/output ports are shown in the page as you select the template need. Currently it is not possible to change chip templates in the middle of a design.

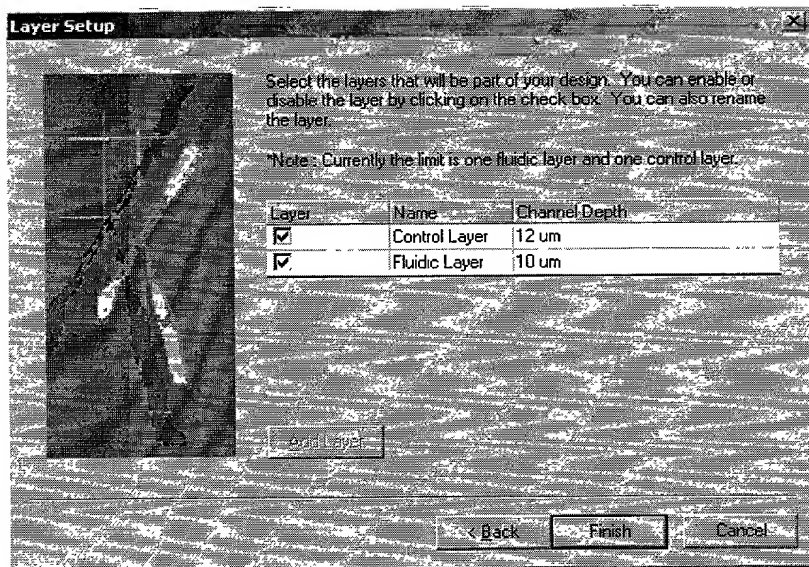


Figure 66 – Layer Setup

The layer setup page allows you to select the layers needed in your design. By default two layers are selected and this is necessary to create active fluidic circuits on the chip. Currently the system is restricted to having a maximum of two layers. Each layer has a channel depth associated with the layer that is fixed in depth.

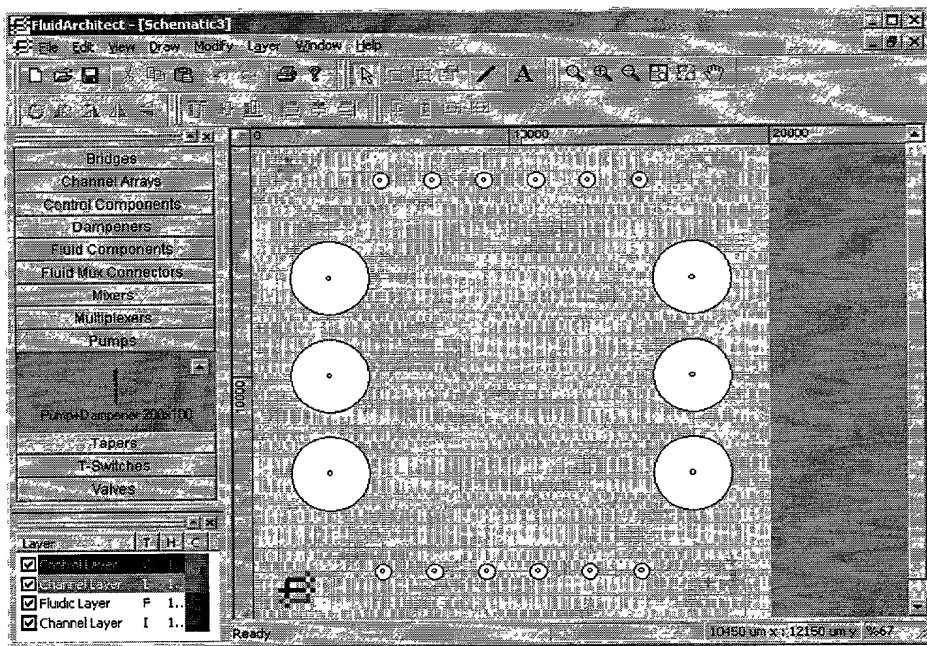


Figure 67 – Completed Design Wizard Setup View

Once you have completed the Design Wizard the chip template chosen will appear in the drawing area as shown in Figure 67. The library components are ready for selection and placement into your design. The layer manager indicates the color of the channels and two which layer they belong as well as the current "Active" layer which is highlighted in black.

## Placing Components

Simply select the library from which to drag and drop the components and place them into the drawing area. Left click on the T-Switches title bar in the Library Manager to select the library. Figure 68 shows the T-Switch library being selected and the T-Switch being placed into the drawing area. As the T-Switch is being dragged and positioned it appears as outline of dashed lines. Once placed

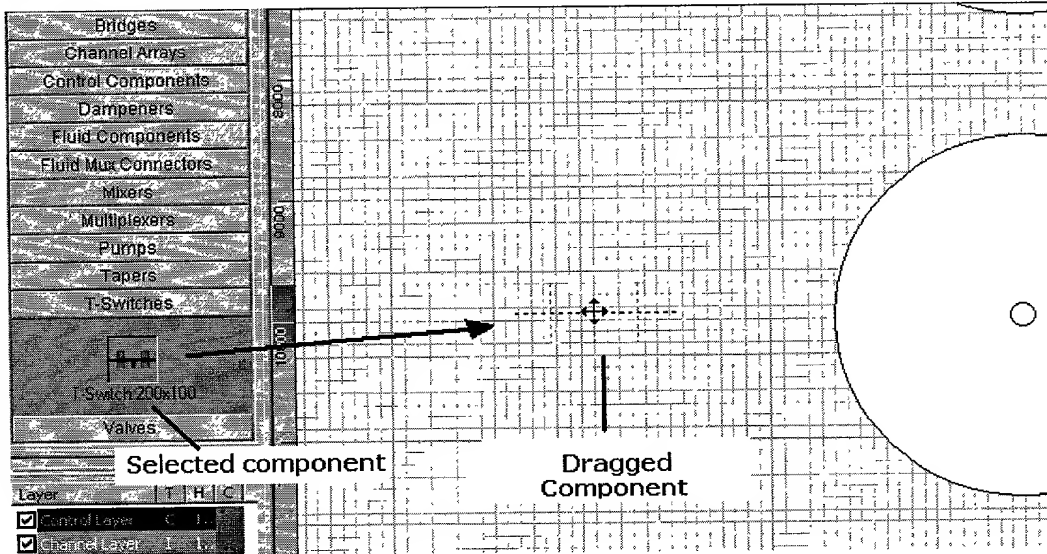


Figure 68 – Placing the T-Switch Component

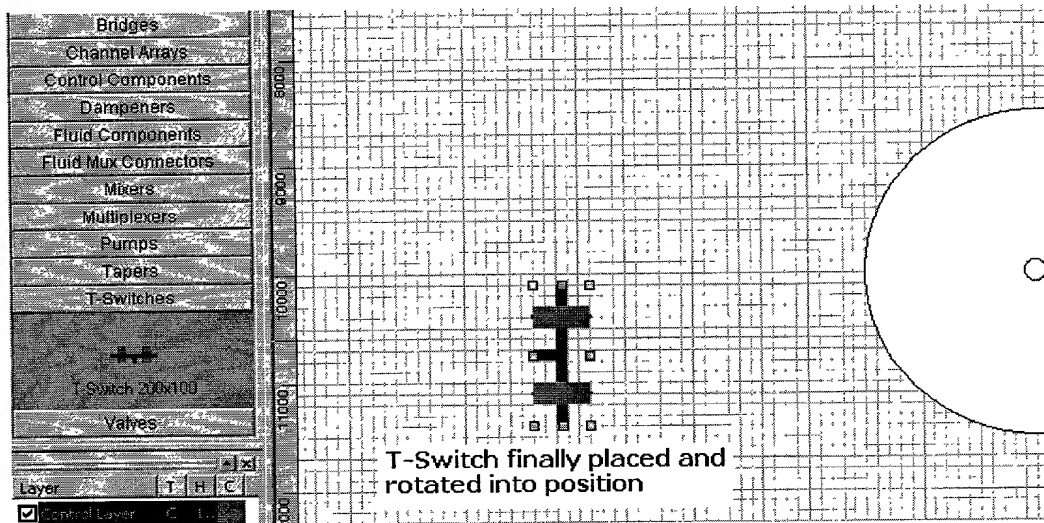


Figure 69 – Finally Placed T-Switch

The placed T-Switch component can now be selected by left clicking it. Once selected, it can be rotated or positioned depending on what is required.

Now, the steps above should be repeated to place the rest of the components for this design.



## Connecting the Components

Once all of the components are placed, they must be connected. The components typically consist of channels from both the fluidic and control layers that are specifically positioned and dimensioned to insure proper operation.

Figure 70 shows the connection of the T-Switch to the "Detection Region", which consists two taper elements and a 30  $\mu$ m channel connecting between the two tapers. Recall that to select a component that only has channel in either the fluidic or control layer, the fluidic or control layer must be set "Active". This can be done in the Layer Manager by left clicking on the desired layer and right clicking to bring up the pop up menu to set the layer "Active" OR this can also be done by right clicking in the drawing area and bring up the pop up menu and selecting *Layer > Control* or *Fluidic*.

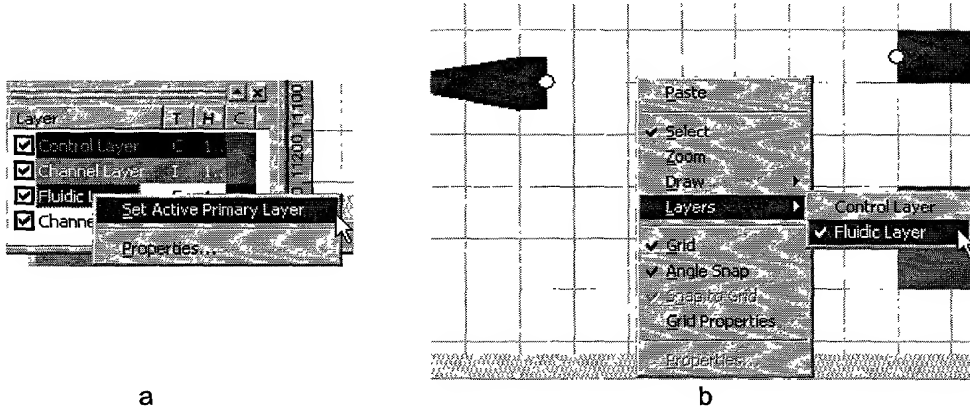


Figure 70. a. Selecting the "Active" Layer through the Layer Manager, b. Selecting the "Active Layer" through the right clicked pop up menu in the drawing area.

In this case the Fluidic Layer needed to be selected as the 30  $\mu$ m – 100  $\mu$ m Taper component was being connected to the input of the T-Switch. Figure 71 shows a channel being drawn from the right end of the Taper component to the input of the T-Switch. Once the cursor turns into the Target Tool a left click will cause a channel to be connected to the unconnected port.

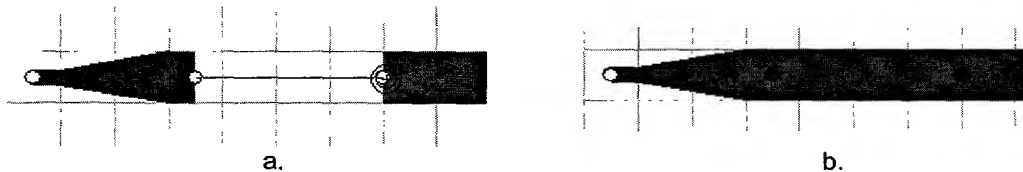


Figure 71 – a. Drawing a Fluidic Connecting Channel, b. Successfully Connected Channel.

## Adding a Vertex While Drawing a Channel

While you are drawing a channel, you can single left click to place a vertex from which you can continue to draw a straight channel or draw the channel orthogonally from the placed vertex. Figure 72 shows an example of how to place a vertex and draw a channel with an orthogonal continuation.

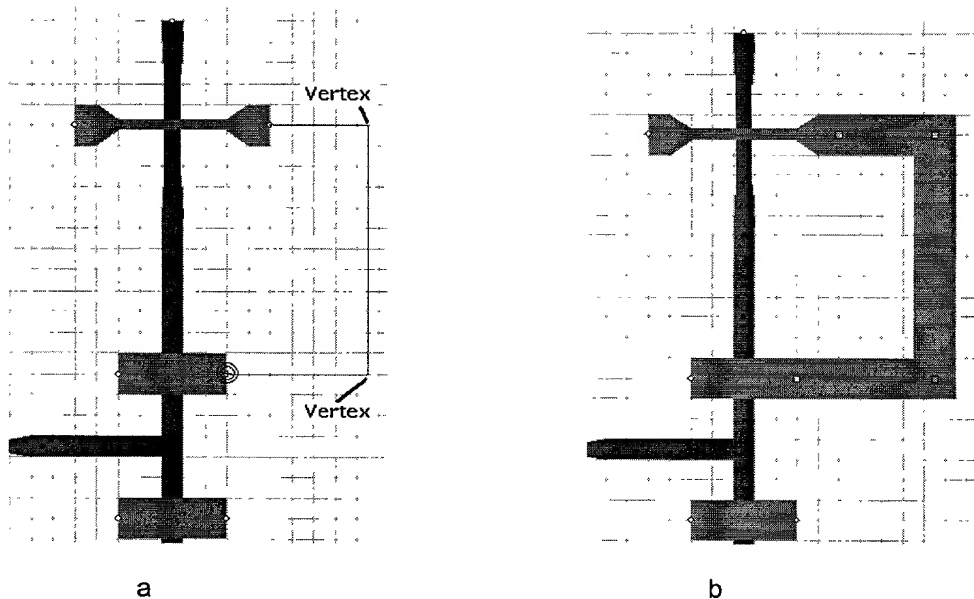


Figure 72 – a. Drawing the control channel and placing the two vertices as shown. b. Completing the connection and the control channel.

## Changing the Channel Widths

The width of the drawn fluidic channel was set to 100  $\mu\text{m}$  as the default. The default setting for a new design is 100  $\mu\text{m}$  for a user drawn fluidic channel and 200  $\mu\text{m}$  for a user drawn control channel. FluidArchitect will keep the default width setting until the user changes the channel width through selecting a channel and changing its width. Figure 73 shows the how the drawn fluidic channel is originally drawn as 100  $\mu\text{m}$  but needs to be resized to match the components that it connects to.

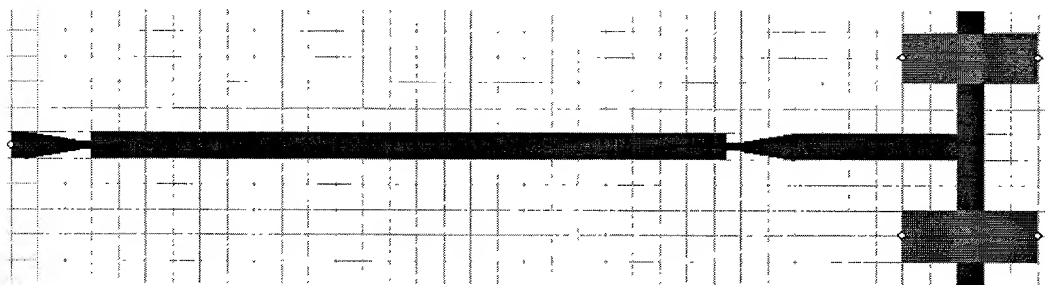


Figure 73 – Drawn Channel Not the Correct Width for Connection

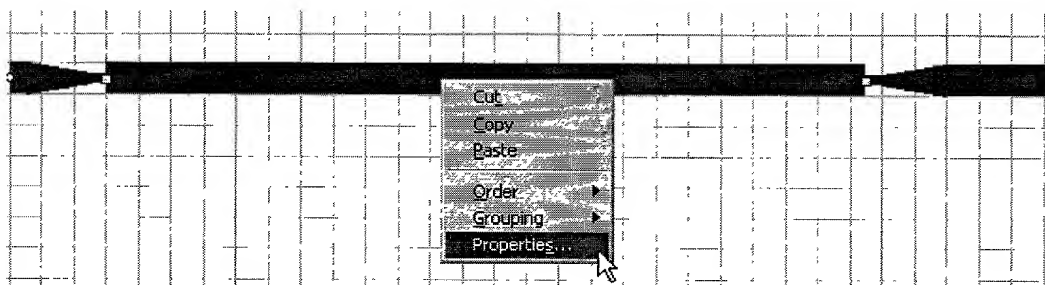


Figure 74 – Open the Channel Properties Dialog to Set Correct Channel Width

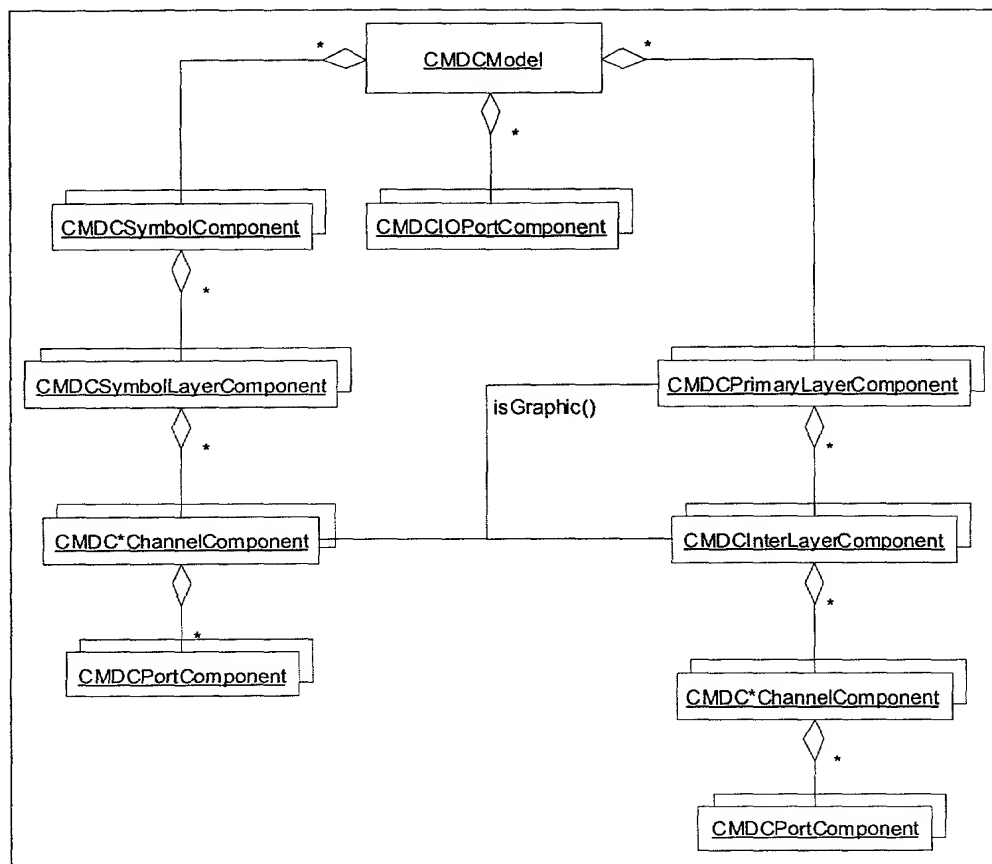






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## APPENDIX D



FluidArchitect Object Diagram

## 1. Framework

1.1. FluidArchitect is based on the Objective Views toolkit from Stingray, a division of Rouge Wave Software. Objective Views provides the MVC (model-view-controller) framework used in FluidArchitect and basic graphical objects, which all FluidArchitect channels are derived. FluidArchitect can be written with any MVC framework, homegrown or purchased. Objective Views was chosen as the initial implementation to expedite development.

1.2. CODComponent is the base class for all graphical components in Objective Views. (COD stands for Class Objective Diagram and precedes all Objective Views classes. Objective Diagram is the legacy name of Objective Views toolkit) Along with providing basic component functionality, drawing, saving, etc., it is also a collection for other CODComponents. All FluidArchitect objects are derived from CODComponent.

## 2. The Model

2.1. The model in the Objective Views MVC is a "canvas", the CODModel class, which provides the object containers. CODModel is derived from the Objective Views base class CODComponent.

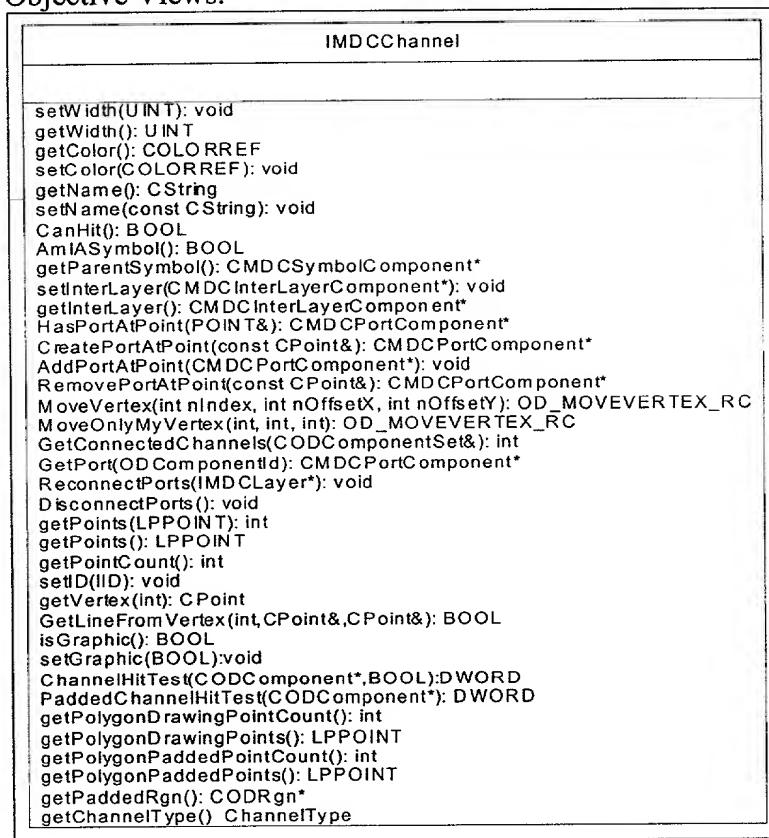
2.2. The model is the main container for all objects in FluidArchitect. The model class is CMDModel. (CMD stands for Class Mycometrix Design Capture, and precedes all FluidArchitect class names).

- 2.3. The model owns primary layers (CMDCPrimaryLayerComponent), of type Fluidic or Control. The model doesn't own channels directly; rather it owns the layers that own the channels.
- 2.4. The model owns the FluidArchitect symbols (CMDCSymbolComponent).
- 2.5. The model owns the Input/Output ports (CMDCIOPortComponent).
- 2.6. The model is responsible for hit testing the entire design, as well as validating operations on channels (move, resize, etc). The model is also responsible for various DRC (Design Rule Checks).

### 3. FluidArchitect Channels

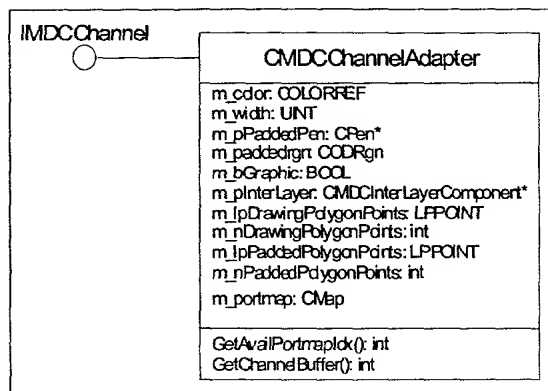
#### 3.1. FluidArchitect Channel Interface: IMDCCChannel

- 3.1.1. The IMDCCChannel interface differentiates the FluidArchitect channel objects from the standard Stingray graphical objects. (IMDC stands for Interface Mycometrix Design Capture). This interface provides accessors into channel specific data. It also provides the interfaces for operations that need to be performed on channels that were not provided by Objective Views.

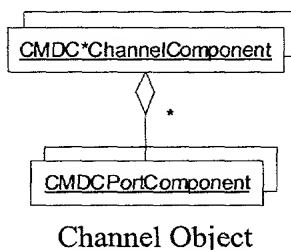


#### 3.2. FluidArchitect Channel Adapter

- 3.2.1. The FluidArchitect channels do not directly implement the interface, IMDCCChannel. Rather, they are derived from the adapter class, CMDCChannelAdapter. The CMDCChannelAdapter class provides the data members required of all FluidArchitect channel components. All data members that are relevant to channels are stored in FluidArchitect objects, not in Object View objects. It also provides default functionality for IMDCCChannel methods where applicable.



### 3.3. FluidArchitect Channels

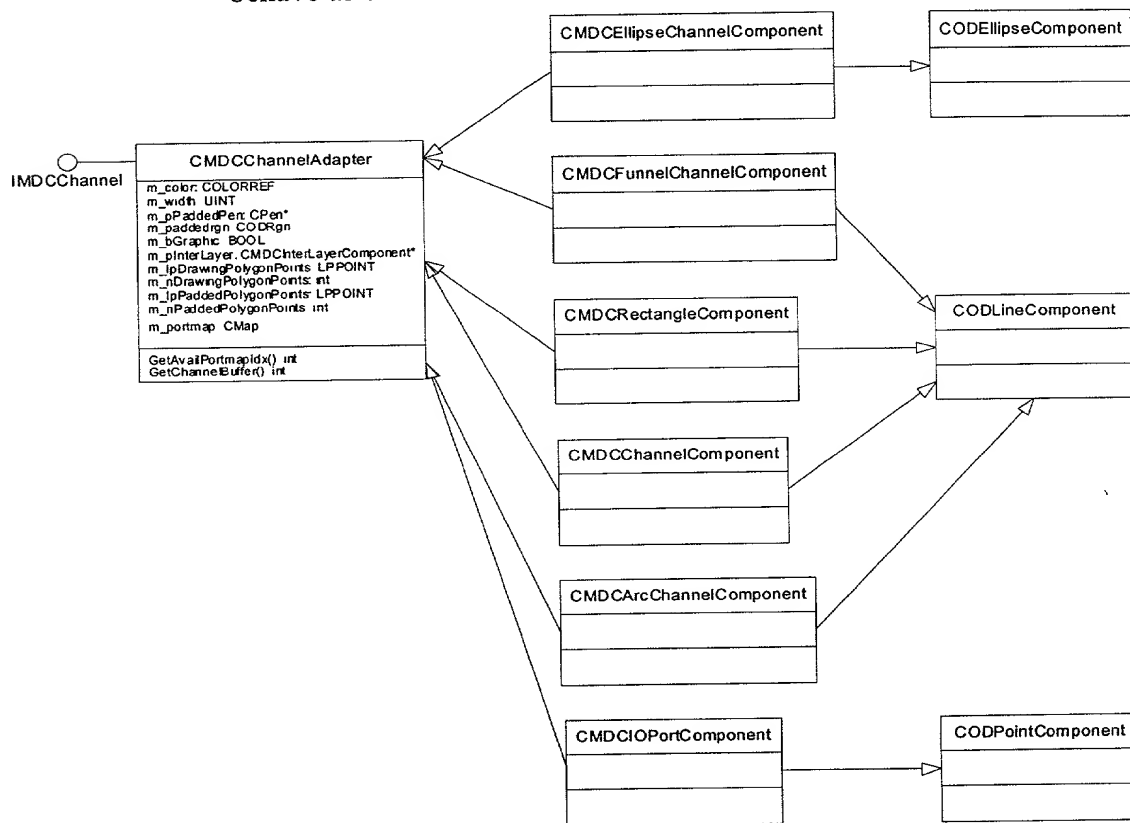


- 3.3.1. All items that will be outputted for product production are channels. This includes control channels, fluid channels and graphics.
- 3.3.2. The FluidArchitect channel components contain ports (CMDCPortComponent). These ports are children of the channel object that allow connections to other ports.
- 3.3.3. Any data member that is specific to a particular type of channel is stored in that channel's structure. All data members that are general to all channel components are stored in the CMDCCChannelAdapter.
- 3.3.4. There are 6 different types of FluidArchitect channels
  - 3.3.4.1. Polyline Channel (CMDCCChannelComponent): This channel is a line of n vertices. It is derived from the CODLineComponent from Stingray to provide the base line functionality and standard CODComponent functionality. This channel is a line with a user specified width. It has a port at each end of the line for connection to other channels. It is derived from CMDCCChannelAdapter to provide the channel interface, channel data members, and default channel functionality.
  - 3.3.4.2. Arc Channel (CMDCArcChannelComponent): Like the CMDCCChannelComponent, the CMDCArcChannelComponent is derived from CODLineComponent to provide basic line functionality. The CMDCArcChannelComponent requires 3 vertices to form an elliptical arc channel. The arc channel has 2 ports, one at either end of the arc.
  - 3.3.4.3. Ellipse Channel (CMDCEllipseChannelComponent): Derived from CODEllipseComponent to provide the ellipse rendering and CMDCCChannelAdapter to implement the channel interface (IMDCChannel). This channel is an ellipse with a user specified width. It has ports at the top, bottom, left and right of the ellipse.
  - 3.3.4.4. Funnel Channel (CMDCFunnelChannelComponent): The funnel channel is used to connect two channels of differing widths. It is derived from CODLineComponent and CMDCCChannelAdapter.

The funnel channel has only two vertices. The funnel channel inherits the widths from its port connections.

3.3.4.5. Rectangle Channel (CMDCTriangleChannelComponent): This provided a solid filled rectangle channel. It is derived from CODPointComponent and CMDCCChannelAdapter. The rectangle channel has ports on the left center, right center, top center, and bottom center. The rectangle does not make use of the width variable, as it is a filled rectangle.

3.3.4.6. I/O Ports (CMDCIOPortChannelComponent): These are the actual input and outputs into the design. They are derived off of CODPointComponent and CMDCCChannelAdapter. Unlike other channels, these channels are static and defined by the current processes for production. They accept connections from any of the other channels. These are specialized channels that do not always behave as other channels.



Channel Class Inheritance

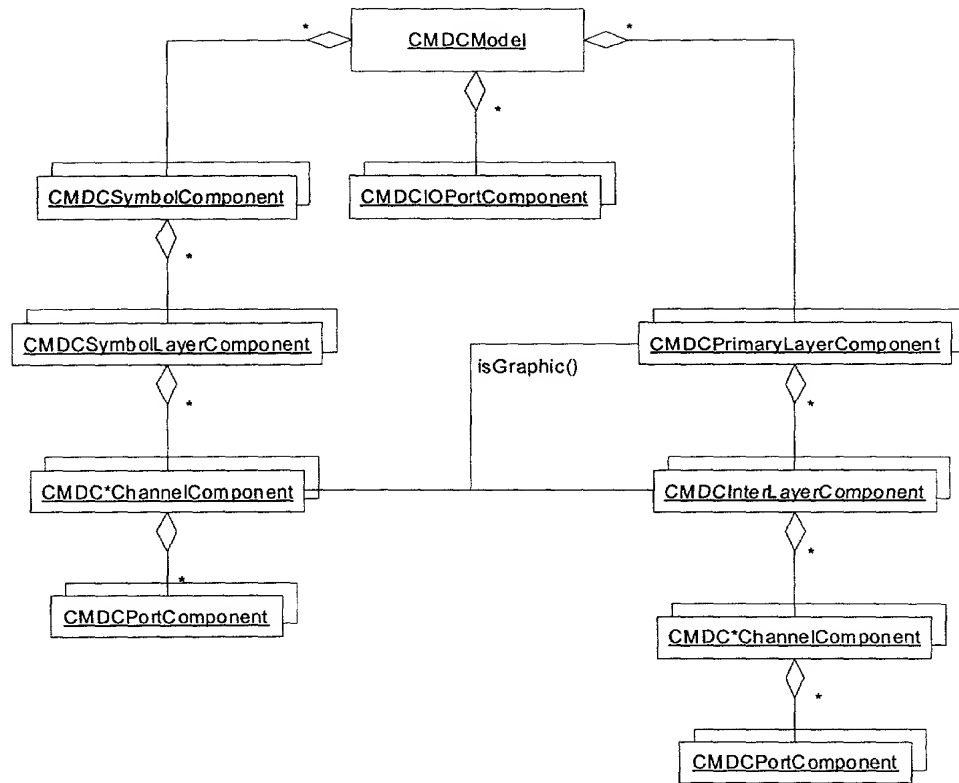
### 3.4. Channel Object Ownership

3.4.1. Channel objects are owned by exclusively by layers, with the exception of the I/O ports. The model itself owns I/O ports so any layer of the design can access them.

3.4.2. Channels that are part of symbols are owned by symbol layers and are associated with channel layers when they are added to the design.

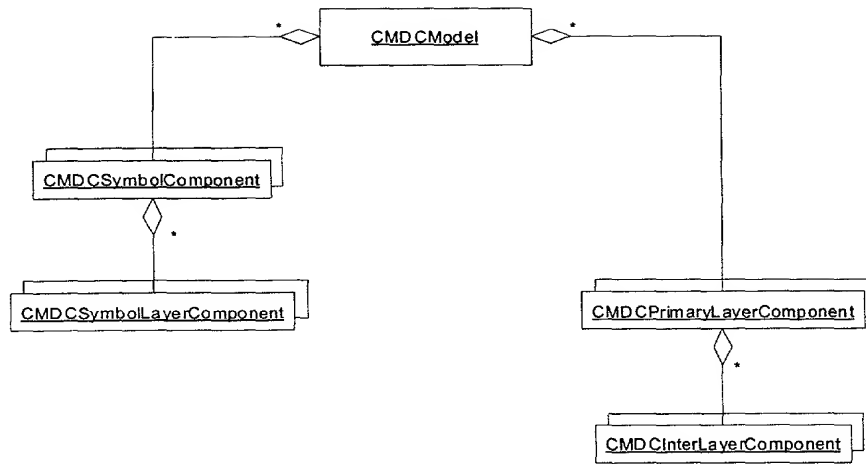
3.4.3. Channels that are part of symbols that are graphics are associated to primary layers instead of channel layers.

3.4.4. Channels own ports. Some channel types have a fixed number of ports; other types allow any number of ports.



Channel Object Ownership

## 4. FluidArchitect Layers

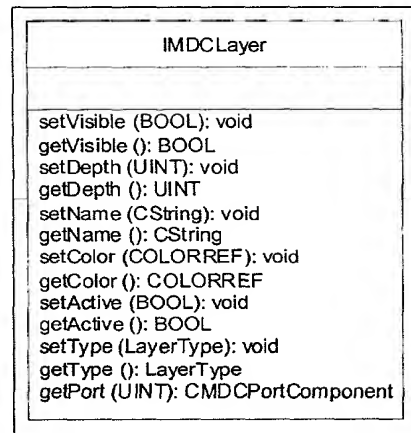


Layer Object Ownership

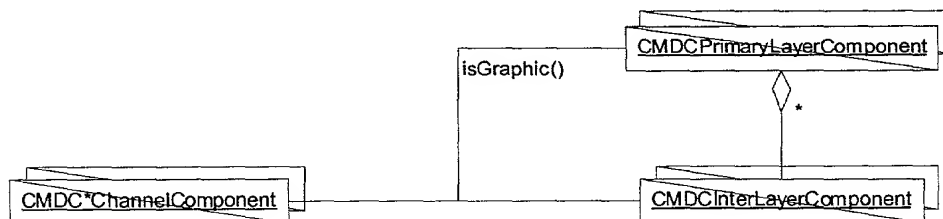
## 4.1. FluidArchitect Layer Interface: IMDCLayer

4.1.1. The IMDCLayer provides a standard CODComponent object with the functionality required for a FluidArchitect layer.

4.1.2. A layer is a container for either other layers and/or FluidArchitect components.



## 4.2. Primary Layers: CMDCPriaryLayerComponent



Primary Layer Object Ownership

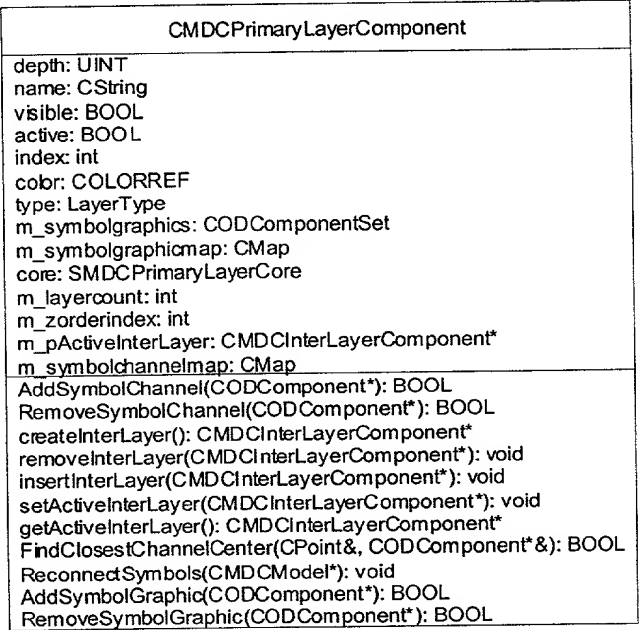
4.2.1. Primary layers are layers that own any number of channel layers.

4.2.2. The only channels that are owned by the primary layers are graphical channels, associated from graphical symbols. Examples of graphical symbols are alignment marks, logos, and identification numbers.

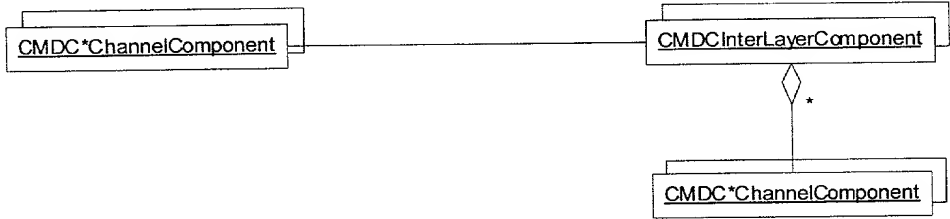
4.2.3. A primary layer has a used defined height that is at least the sum of all its channel layer's heights.



- 4.2.4. Primary layers are typed to describe their functionality. Currently there are only two types of primary layers: Fluidic and Control.
- 4.2.5. A Primary layer can have any number of channel layers.

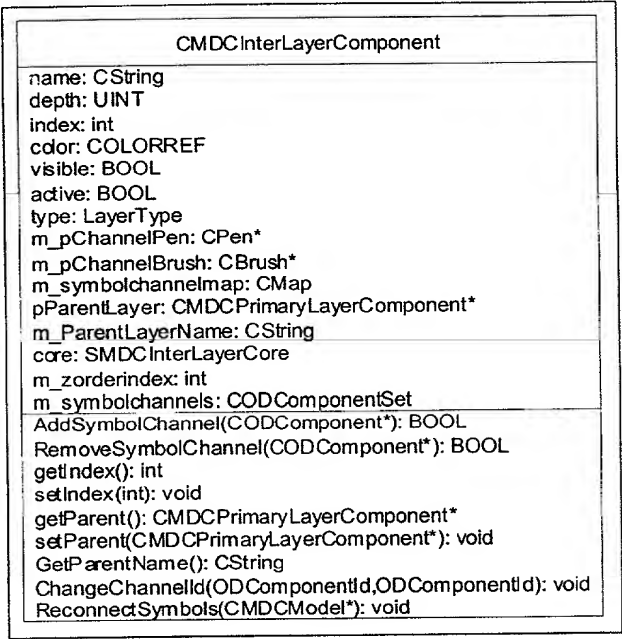


4.3. Channel Layers: CMDCIinterLayerComponent



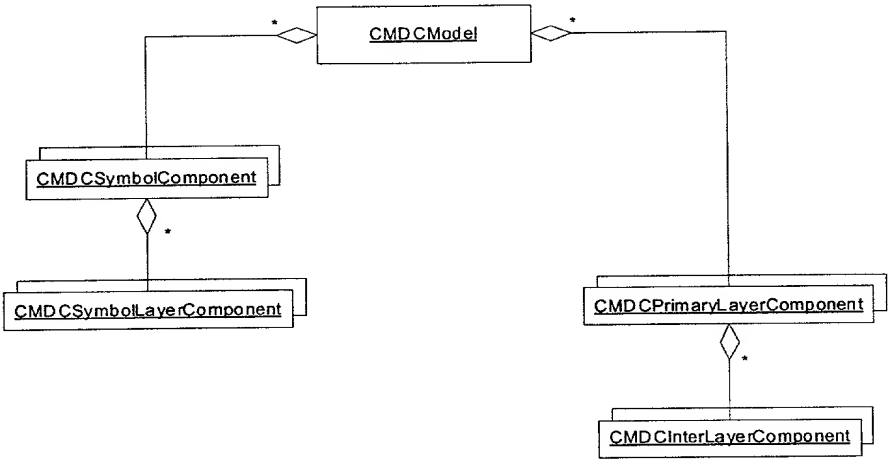
Channel Layer Object Ownership

- 4.3.1. A channel layer has a user-defined height that all channels on the layer will inherit.
- 4.3.2. Channel layers only have a type of Interlayer. They inherit their primary layer's type for functionality.
- 4.3.3. A channel layer can have only one primary layer parent.
- 4.3.4. Channel layers own the actual channels that the user draws using the drawing tools.
- 4.3.5. Channels contained in symbols are linked to the interlayer, but not owned by them. This allows the layer access to all channels that are to be outputted on the layer.

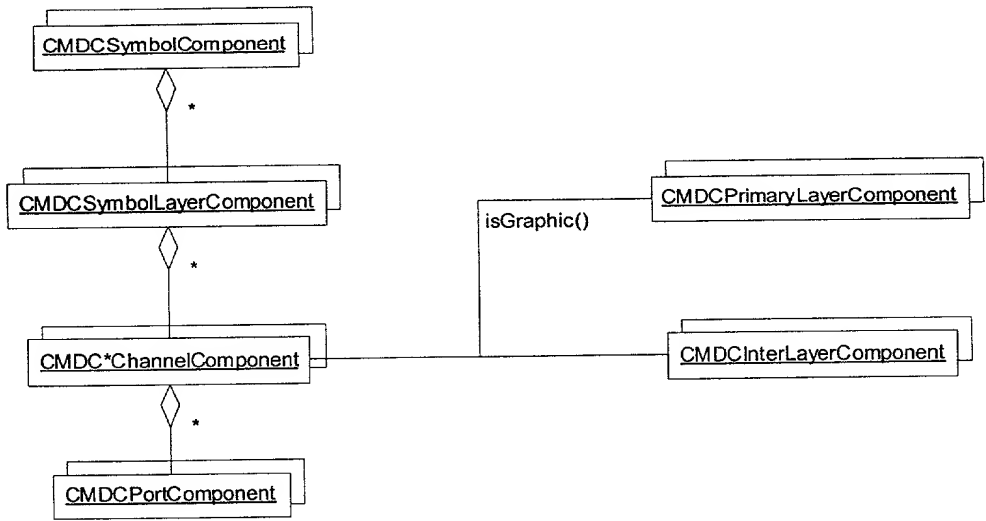


4.4. Layer Object Ownership

- 4.4.1. Primary layers are owned exclusively by the model. The model can own any number of primary layers.
- 4.4.2. Primary layers must own at least one channel layer, but may own any number of them.
- 4.4.3. Channel layers own channels, but do not own any layers. Channel layers may only be owned by one primary layer.
- 4.4.4. Symbols own symbol layers. Symbol layers own the channel objects. These objects are linked to the channel layer or primary layer they reside on when placed in the design.

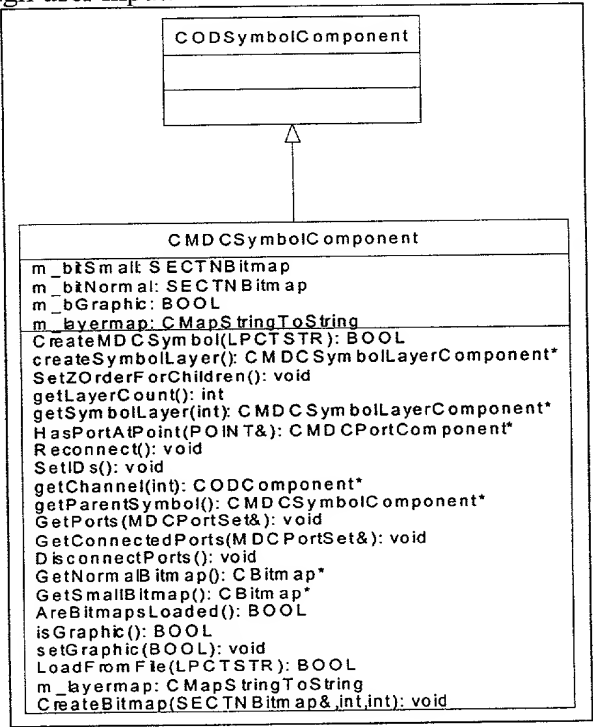


Layer Object Ownership

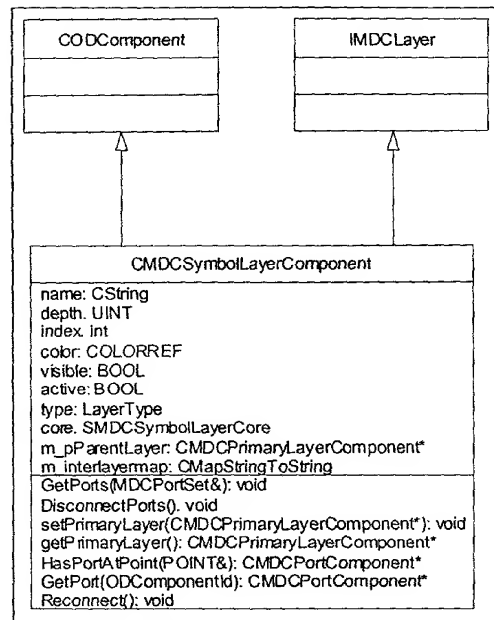


Symbol Object Ownership

- 5.1. CMDCSymbolComponent
- 5.1.1. A symbol is a collection of layers. Each layer owns channels.
  - 5.1.2. Symbols are added to the canvas via a drag and drop method.
  - 5.1.3. Symbol layers are matched up the primary layers, either via an “active” layer, or through user input.



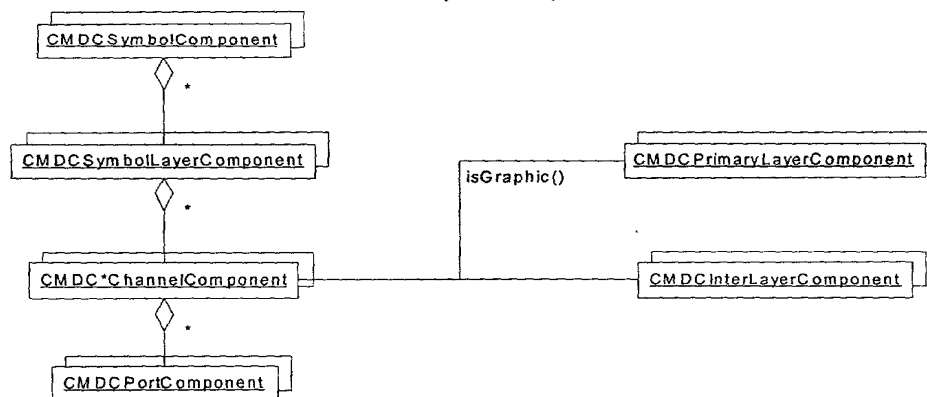
5.2. CMDCSymbolLayerComponent



- 5.2.1. Symbol layers can own any number of channels.
- 5.2.2. Channels from the symbol layer are linked to the active interlayer from the associated primary layer.
- 5.2.3. Graphical channels from the symbol layer are linked to the active primary layer, or a user specified layer.

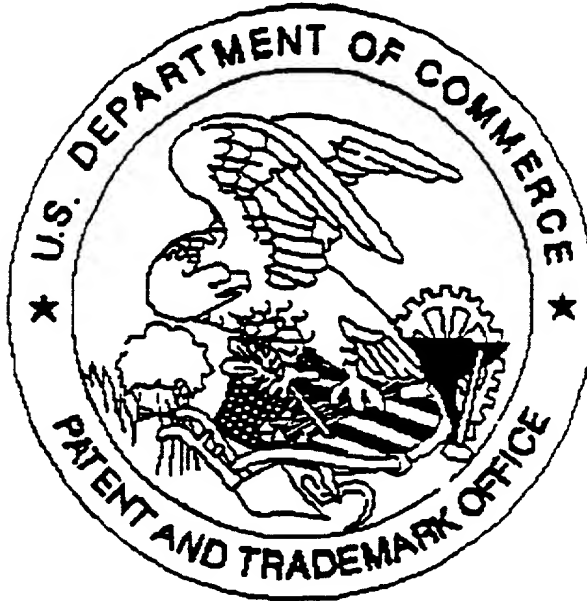
### 5.3. Symbol Object Ownership

- 5.3.1. Symbols are owned exclusively by the model.
- 5.3.2. A symbol must own one symbol layer, but may own any number of them.
- 5.3.3. A symbol layer may own 0 or more channels.
- 5.3.4. The channel layer or primary layer has no control over the existence of their linked channels from the symbol layer.



Symbol Object Ownership

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